Education in the zoo: A study of the relationship between education, zoo visitors and animal behaviour

Courtney Keane Collins, B.A., M.Sc.

A thesis submitted in fulfilment of the requirements for the degree of Doctor of Philosophy

School of Biological, Earth and Environmental Sciences,

University College Cork

Head of School: Professor Andy Wheeler

Supervisors: Dr Ruth Ramsay (School of BEES),

Dr Declan Kennedy (School of Education)

December 2018

Contents

Candidate's Declaration:

I declare that this thesis is my own work, and it has not been submitted for another degree either at University College Cork or at another university. All external references and sources are clearly acknowledged and identified within the contents. I have read and understood the regulations of University College Cork concerning plagiarism.

Signed: ____

Courtney K. Collins

Abstract

One of the primary stated goals of zoos is education of the public. Yet, zoos have been criticised for failing to show evidence of their claims to be educators. Because of the general lack of research surrounding education in the zoo, even less is known about how education relates to the other areas of zoo research. This thesis presents a range of integrated studies which explore the relationship between zoological education, zoo visitors and animal behaviour. First, the effect of the zoo setting and visitors on the behaviour of ring-tailed lemurs (*Lemur catta*) and Gentoo penguins (*Pygoscelis papua*) was considered. Generally, it was found that the animals had habituated to visitors and were not disturbed by them. Next, the effect of zoological education on children's learning was assessed using pre- and post-surveys. Some groups of children participated in an educational intervention (EI), during which children made enrichment devices for animals. The results indicated that children who participated in the EI were more likely show increases in knowledge and behaviour than those who did not. Finally, children's behaviour and conversation and animals' behaviour were simultaneously recorded as the children viewed the animals. Overwhelmingly, children who participated in the EI engaged in fewer negative behaviours towards the animals, made more positive and fewer negative comments than those who did not participate in the EI. There was little effect on the animals' behaviour of being observed by either group. This thesis represents the most detailed research into children's zoological education in Ireland and is one of the first studies to observe children's and animals' behaviour simultaneously, while considering the effect of education. It is a significant source of information for both educators and zoological institutions in regards to the development of educational material to enhance learning in the zoo and to promote pro-conservation behaviour change and positive animal welfare. Additionally, it established that the species included here were not disturbed by visitor interactions, and in a supervised capacity may be suitable for limited animal-visitor interactions.

Acknowledgements

My sincere appreciation and earnest thanks are extended to my supervisors, Dr Ruth Ramsay and Dr Declan Kennedy, whose wisdom, guidance and encouragement made this project possible. Dr Kennedy introduced me to the formal theories of education and expanded my thinking with regard to informal science education. Dr Ramsay's belief in the research allowed me to explore a topic of great personal interest to me, and her positive attitude was instrumental in the completion of this project. I would also like to thank Mr Sean McKeown, director of Fota Wildlife Park, and Dr Kevin Flannery, director of Dingle Aquarium, for making this research possible. I would particularly like to acknowledge Maire O'Shea and Lynda McSweeney-Walsh, for sharing their valuable time and years of experience with me, as well as the rest of the staff at Fota and Dingle for your assistance over the years.

Within UCC, I would like to thank the staff and my fellow postgraduates in the BEES department for your help and encouragement. I am indebted to Dr Thomas Quirke and Dr Ilse Corkery for their statistical guidance throughout this project. Thank you for sharing your enthusiasm and knowledge of research and statistics with me. Also, Dr Marcin Szczerbinski and Dr Angela Veale of the Applied Psychology department and Dr Colette Murphy at TCD for your help with the methodology and development of the survey. I received a research grant from the Irish Federation of University Teachers and financial support from the BEES department for which I am very grateful. A special thank you to all of the schools, who participated in this project - without you this research would not have been possible.

Thank you to my family, especially my mother and my sister, and my friends for your belief in me and your support, even when things were difficult. To my husband, Gearóid, and my daughters, Mary and Charlotte, I thank you from the bottom of my heart. Without your love, patience, acceptance, understanding and unwavering faith in me, I could not have done it!

This work is dedicated to the memory of my father, Dr Francis J. Keane.

Chapter 1

General Introduction

1.1 Background

With over 700 million people visiting zoos and aquariums worldwide each year, zoos are in a leading position to be advocates of environmental education (Gusset and Dick, 2011; Moss et al., 2015). Education, along with conservation, is the most prominent mission theme stated by zoos in the United States (Patrick et al., 2007), though other common goals include animal welfare, research, and entertainment (Fernandez et al., 2009). The institutions included in the current study belong to the British and Irish Association of Zoos and Aquariums (BIAZA), which, as part of its mission statement, includes delivering high quality environmental education (BIAZA, 2018). Yet, zoos have recently been criticised for failing to provide empirical evidence that they are in fact educating visitors (Jensen, 2011; Moss and Esson, 2013), and many visitors reported that entertainment was their main reason for visiting a zoo (Reade and Waran, 1996). The conflict between education and entertainment can be challenging for zoos to balance, and recently interactive animal experiences, free-range and walk-through exhibits have become more prominent in zoos, which may be a way to satisfy both of these goals (Woolway and Goodenough, 2017). However, to date there is only limited research about how these activities affect the animals or the visitors involved.

Perhaps even more challenging than balancing visitor entertainment and education, is balancing visitor needs with animal welfare (Fernandez et al., 2009). If the public visit the zoo for entertainment and education, but then cause stress to captive animals as a result of their presence, then the stated goals of zoos may be in opposition (Hosey, 2000; 2005; Fernandez et al., 2009). Yet, limiting visitor access to animals is not financially viable for zoos (Hosey, 2005; Fernandez et al., 2009). Furthermore, visitors are more likely to engage in pro-conservation behaviour, if they develop a positive emotional connection to wildlife during a zoo visit, which may be more likely to occur at close proximity (Hosey, 2005; Fernandez et al., 2009; Skibins and Powell, 2013). Environmental enrichment has been used in zoos to reduce negative visitor effects (Carder and Semple, 2008), and to encourage higher levels of activity, which may enhance visitor enjoyment (Tofield et al., 2003). However, a surprising gap in the literature exists surrounding the role that enrichment might play in balancing the aforementioned different goals of the zoo.

While studies that evaluate visitor learning in the zoo are becoming more prevalent, those involving children are scarce. One large-scale zoological education study in the United States reported that zoo and aquarium visits positively impacted adults' attitudes towards animals and conservation (Falk et al., 2007). A UK based study, that did include children, reported significant knowledge gain as a result of a zoo visit (Jensen, 2011; 2014). A world-wide project, that evaluated zoos' contribution to raising awareness of biodiversity, found significant increases in biodiversity understanding and awareness after a zoo visit (Moss et al., 2015). However, as with environmental education, the ultimate goal of zoological education should be pro-conservation action and behaviour change, not just knowledge gain (Ogden and Heimlich, 2009). Although behaviour change can be challenging to show on-site at the zoo (Smith et al., 2008), a limited number of studies have suggested that education could be a way to improve visitor behaviour while viewing animals (Kratochvil and Schwammer, 1997; Orams and Hill, 1998; Bexell et al., 2013). Yet, these studies did not consider if a change in visitor behaviour led to a change in the animals' behaviour.

With few exceptions, previous studies have reported only one part of the complex relationships present in the zoo, even though these areas are intricately connected. For example, Price et al. (1994) considered visitors' response to free-ranging and caged primates but did not report the animals' response to the visitors. In contrast, Jones et al. (2016) reported a neutral to positive effect of a visitor feeding experience on crowned lemur (*Eulemur coronatus*) behaviour, but they did not offer evidence of how the experience affected the visitors. A few animal-visitor interaction studies have assessed responses of both animals and people, but this generally only included a limited evaluation of, for example, animal proximity to visitors or activity level, and visitor noise level or exhibit stay time, and none of these studies focused on children as visitors (Anderson et al., 2003; Mun et al., 2013; Sherwen et al., 2014). Thus, a lack of understanding of the relationship between several areas of zoo research currently exists.

This thesis investigates how the zoo setting, including environmental and visitor variables, affects two species in captivity. Then it examines the impact of zoological education on primary school children's knowledge, attitude and behaviour towards those animals. A hands-on educational intervention, during which children made environmental enrichment devices for captive animals, was purposefully developed for the treatment group of children in this study. Additionally, the behaviour of both the animals and children is simultaneously observed during viewing sessions with control and treatment groups.

1.2 Institutions and animals

Out of eight BIAZA institutions in Ireland, two were chosen for this study. Fota Wildlife Park, winner of the prestigious Sandford Award (since 2008) for heritage education, was included because of its commitment to delivering high quality education, as well as its commitment to research and the unique setting where some of the animals are free-ranging and most are in naturalistic enclosures. Dingle Aquarium, the second study site, also offers high quality education and is committed to introducing students to the concepts of biodiversity and conservation. However, its exhibits are uniquely different from those at Fota, giving a rare opportunity to examine the effect of different enclosure designs on the chosen captive animals' behaviour and children's learning.

Three different species were chosen for the study: ring-tailed lemurs (*Lemur catta*), Humboldt penguins (*Spheniscus humboldti*) and Gentoo penguins (*Pygoscelis papua*). The animals included in this study were considered popular by visitors (M. O'Shea, Dingle Aquarium, pers. comm., November 6, 2014; T. Power, Fota Wildlife Park, pers. comm., July 27, 2016), who may be drawn to their humanlike, charismatic behaviour and bold colour patterns. Both lemurs and penguins were listed by zoo visitors as an animal they would most like to see (Carr, 2016). Additionally, both lemurs and penguins had recently featured in the media at the time that the research was conducted, which may increase visitor interest (Wagoner and Jensen, 2010).

As habitat loss and hunting continue to threaten lemurs in the wild (IUCN, 2017), zoos may become more important for this species. Yet, despite being a popular and commonly held animal in zoos (Species 360, 2018), there is little research on the behaviour of ring-tailed lemurs in captivity, with the focus of most previous research occurring on wild populations (Gould et al., 1999; Sauther et al., 1999), but see Ramsay (1995) who carried out some research on the lemurs at Fota. In the UK, lemurs have become increasingly popular in interactive visitor experiences (Jones et al., 2016), and they are often kept in free-ranging exhibits. The lemurs' welfare is a primary concern of Fota Wildlife Park. Therefore, more information is required on how well the lemurs are suited to the free-range environment, if visitor interactions have any impact on them and how well visitors learn from observing them.

With regard to the two species of penguin, Humboldt penguins are kept at Fota Wildlife Park while the Gentoo penguins are at Dingle Aquarium. Though the wild population of Gentoo penguins is currently stable, Humboldt penguins are listed as vulnerable in the wild for a variety of reasons (IUCN, 2017). However, as climate change continues to destroy ocean habitats both species of penguin may face threats in the future. Studies on wild populations of penguins offer little information on penguins' behaviour and ambiguous results on the effect of tourist presence (e.g. Culik and Wilson, 1991; Cobley and Shears, 1999). In captivity, only minimal research has occurred on penguin behaviour. One study suggests that penguins habituate to visitor presence over time (Ozella et al., 2015), whereas another has found that penguins may be bothered by visitor presence (Sherwen et al., 2015).

Previously, research on both visitor effects and educational studies in the zoo setting have primarily focused on adults. However, children constitute a large percentage of visitors to zoos every year, and since it is children who will make environmental decisions in the future, it is a societal task to equip them with the proper knowledge and skills to bring about positive environmental change (Davis, 1998). Additionally, both of the institutions included in this thesis have programmes specifically designed for children and school groups. Therefore, the parts of this thesis specifically investigating education in the zoo, have comprised school groups, generally aged 9-12 years, as study participants. However, the two chapters that consider the effect of visitors on lemur and penguin behaviour include visitors of all ages. Fota Wildlife Park reports that over 450,000 visitors and 15,000 students visit the park every year (L. McSweeney, Head of Education at Fota Wildlife Park, pers. comm., 2017) and Dingle aquarium has approximately 100,000 visitors each year, 5,000 of whom are students (M. O'Shea, General Manager at Dingle Aquarium, pers. comm., 2018), making children a readily accessible yet under-studied group.

Throughout the project, all animal behaviour was recorded using either instantaneous scan sampling or behaviour sampling (Altmann, 1974; Martin and Bateson, 2007). Data collection with children was triangulated to gain insight into learning from different approaches (Cohen et al., 2007; Wellington and Sczcerbinski, 2007). The multi-method approach used here builds on previous research by using a traditional control/treatment, pre-/post-survey design, but additionally it uses more innovative methodologies such as conversational content analysis (Patrick and Tunnicliffe, 2013) and a pre-categorised ethogram to record children's behaviour as they viewed animals (Bexell et al., 2013).

1.3 Aims and objectives

'There is no doubt that the environment is in a critical state' (Ogden and Heimlich, 2009; p. 359), and although worldwide research is being done to combat environmental problems, for the average citizen these issues can seem far removed from their daily lives. Hence, zoos, frequented by millions of people all over the world, play a vital role in educating the public about environmental problems. This research offers a comprehensive investigation into several important relationships in the zoo setting and their interconnectedness. One of the objectives of this research was to examine whether an educational intervention enhanced existing environmental education programmes at Fota and Dingle, through promoting pro-conservation behaviour and to consider if the welfare of captive animals can be improved through visitor education. The research is presented in a series of integrated studies which examine:

1) The effect of different environmental and visitor variables on the behaviour of free-ranging ring-tailed lemurs and zoo-housed Gentoo penguins;

2) the impact of an educational intervention on children's knowledge, attitude and behaviour in the zoo setting, during: a one-day school tour, a five-day long camp and a six-month follow-up study;

3) the effectiveness of using education to control visitor behaviour as visitors view captive animals' and the corresponding response from the animals;

4) an evaluation of children's conversation as they view animals and an assessment of the relatedness of knowledge and behaviour in the zoo.

1.4 Chapter summaries

The following summaries outline the content of each chapter in this thesis.

Chapter 2. Literature review

Since this inter-disciplinary thesis includes a diverse range of subjects including: several areas of zoo research, psychology and education, an extensive literature review was necessary in order to develop an in-depth understanding of the disciplines included in this research. This chapter offers a broad review of the literature surrounding the areas of 1) educational research including: informal science education, environmental education and zoological education and 2) zoo-based research including: exhibit design, visitor effects, human-animal interactions in the zoo and environmental enrichment. However, where the literature is covered in detail in a subsequent chapter, only an overview is given.

Section A. Animal behaviour: Chapters 3 and 4

This section includes two chapters examining the behavioural response of two species of zoo animal to the captive environment. First, in Chapter 3 the effects of several environmental and visitor variables on the behaviour of free-ranging ring-tailed lemurs (*Lemur catta*) at Fota Wildlife Park were investigated using general estimating equations (GEEs). Specific lemur-visitor interactions were also examined. Next, in Chapter 4, general linear models (GLMs) were used to determine the effect of visitor number, visitor behaviour and the presence of environmental enrichment on the behavioural diversity level, pool use and nest behaviour in Gentoo penguins (*Pygoscelis papua*) at Dingle Aquarium.

Section B. Children's education: Chapters 5 and 6

This section consists of two chapters focusing on children's learning in the zoo setting. In Chapter 5, the effects of a one-day school tour at Fota Wildlife Park and Dingle Aquarium on children's knowledge, attitude and behaviour are examined, while taking into consideration demographic variables such as gender and school location. Chapter 6 builds on the results of the previous chapter by investigating a longer duration education programme (a five-day camp at Fota Wildlife Park) on children's learning, and additionally considers if learning is retained six months after the visit to Dingle Aquarium. Data were collected using pre- and post-surveys, and results are presented using descriptive statistics, but also analysed using general linear models. Some groups of students participated in the purposefully developed educational intervention (EI) and are referred to as treatment groups, those that did not participate in the class are the control groups. Differences in learning outcomes between the two groups and other variables tested are discussed. In Chapters 5 and 6, results and discussion of the research are combined followed by a short general discussion.

Section C. Connections within the zoo: Chapters 7, 8 and 9

This section continues to assess the effect of education in the zoo but uses different methodology. First, in Chapter 7, children's and animals' behaviour are simultaneously recorded during viewing sessions using ethograms with pre-designated categories of behaviour for both the children and the animals. Next, Chapter 8 considers the effect of education on children's conversation as they view animals in the zoo setting. Both positive and negative comments were observed and recorded. Again, in this section the effect of participation in the educational intervention is considered and discussed. General linear models as well as non-parametric tests were used to analyse the data. In Chapters 7 and 8, the results and discussion of the research are combined, followed by a short general discussion. Finally, Chapter 9 considers if knowledge, as demonstrated in the survey, is related to children's behaviour as they viewed animals. A Spearman's rank order test is used to test for an association between total group survey score and the groups' behaviour towards the animals.

Chapter 10. Summary and conclusions

This chapter offers a general summary and conclusions of the thesis. The overall findings of the thesis are discussed and recommendations for future work are made.

Appendices

Included in the appendices is additional data not presented in the thesis, data excluded from the analysis of certain sections of the study and the corresponding reason, the surveys used during the research, the PowerPoint presentation which was used during the educational intervention, and the PDFs of two papers published so far from this thesis. Individual chapters also have appendices including additional material that relates specifically to that chapter.

1.5 Abbreviations and definitions used throughout the thesis.

Abbreviations

AZA – Association of Zoos and Aquariums

BD – Behavioural diversity

BIAZA – British and Irish Association of Zoos and Aquariums

CC – Conservation Caring

CMF – Charismatic Mega Fauna

DA – Dingle Aquarium

DEIS (school) – Delivering Equality of Opportunity in Schools

EE – Environmental Education

EI – Educational Intervention

FCM - Faecal cortisol metabolites

FGM - Faecal glucocorticoid metabolites

FWP – Fota Wildlife Park

HAB – Human-animal bond

HAI – Human-animal interaction

HAR – Human-animal relationship

IOR – Inter-observer reliability

RSPCA - Royal Society for the Prevention of Cruelty to Animals

TCOR - Tunnicliffe Conversation Observation Record

Definitions

Affective domain – part of Bloom's Taxonomy, it involves emotional and attitudinal learning (Bloom, 1956).

Anthropocentric - regarding humans as the most important element in existence (Merriam Webster dictionary, on-line).

Anthropomorphic - attributing human characteristics to non-human things (Merriam Webster dictionary, on-line).

Browse – plants, grasses and small branches that are given to a zoo-housed animal as a form of enrichment.

Constructivism – learning is based on the construction of knowledge; the learner is an active participant (Hein, 1998).

Data triangulation – a type of methodology that uses two or more methods of collecting data in the same study; a mixed-method approach (Cohen et al., 2007).

Enrichment – environmental stimuli (food or non-food) provided to zoo-housed animals to improve their psychological and physiological wellbeing (Swaisgood and Shepherdson, 2005).

Ethogram – a tool for categorising and recording animal behaviour.

Exhibit design: captive animals' enclosures have been categorised to describe how they have evolved since zoos first opened.

- First generation – bare, featureless, barred cage or concrete pit; often housing a solitary animal (Moss et al., 2010).
- Second generation – basic design with perhaps some 'cage furniture;' concrete, perhaps with a water moat; some consideration for animal welfare (Moss et al., 2010, p. 12).
- Third generation – themed (sometimes with native plants) to resemble an animal's natural ecosystem; appropriate social groupings; enrichment may be present; discrete barriers (Moss et al., 2010).

Tbilisi Declaration - a declaration issued in 1977 after the first intergovernmental conference on environmental education organised by UNESCO was held in Tbilisi, Georgia (USSR) from October 14-26, 1977. One of the main objectives of environmental education outlined at the conference was that environmental education should strive for pro-conservation behaviour change and the development of new patterns of behaviour to help the environment.

Transmission-absorption model of learning – learning is a linear process, the learner accumulates knowledge as they experience education (Hein, 1998).

1.6 References

Altmann, J. (1974). Observational study of behavior: sampling methods. *Behaviour*, 49(3), 227-266.

Anderson, U. S., Kelling, A. S., Pressley-Keough, R., Bloomsmith, M. A. & Maple, T. L. (2003). Enhancing the zoo visitor's experience by public animal training and oral interpretation at an otter exhibit. *Environment and Behavior*, 35(6), 826-841.

Bexell, S. M., Jarrett, O. S. & Ping, X. (2013). The effects of a summer camp program in China on children's knowledge, attitudes, and behaviors toward animals: A model for conservation education. *Visitor Studies*, 16(1), 59-81.

Bloom, B. S. (1956). *Taxonomy of educational objectives. Vol. 1: Cognitive domain*. New York: McKay, 20-24.

British and Irish Association of Zoos and Aquariums, 2011 - 2018. (BIAZA) Our Vision and Mission. https://biaza.org.uk/our-vision (On-line). Date last accessed July 13, 2018.

Carder, G. & Semple, S. (2008). Visitor effects on anxiety in two captive groups of western lowland gorillas. *Applied Animal Behaviour Science*, 115, 211-220.

Carr, N. (2016). Ideal animals and animal traits for zoos: General public perspectives. *Tourism Management*, *57*, 37-44.

Cobley, N. D. & Shears, J. R. (1999) Breeding performance of Gentoo penguins (*Pygoscelis papua*) at a colony exposed to high levels of human disturbance. *Polar Biology*, 21, 355-360.

Cohen, L., Manion, L. & Morrison, K. (2007). *Research methods in education*. Routledge. London and New York.

Culik, B. & Wilson, R. (1991) Penguins crowded out? *Nature*, 351, 340-340.

Davis, J. (1998). Young children, environmental education, and the future. *Early Childhood Education Journal*, *26*(2), 117-123.

Falk, J. H., Reinhard, E. M., Vernon, C. L., Bronnenkant, K., Deans, N. L. & Heimlich, J. E. (2007). *Why zoos & aquariums matter: Assessing the impact of a visit to a zoo or aquarium.* Silver Spring, MD: Association of Zoos & Aquariums.

Fernandez, E.J., Tamborski, M.A., Pickens, S.R. & Timberlake, W. (2009). Animal-visitor interaction in the modern zoo: conflicts and interventions. *Applied Animal Behaviour Science*, 120, 1-8.

Gould, L., Sussman, R.W. & Sauther, M. L. (1999). Natural disasters and primate populations: the effects of a 2-year drought on a naturally occurring population of ring-tailed lemurs (*Lemur catta*) in southwestern Madagascar. *International Journal of Primatology*, 20(1), 69-84.

Gusset, M. & Dick, G. (2011). The global reach of zoos and aquariums in visitor numbers and conservation expenditures. *Zoo Biology*, 30(5), 566-569.

Hein, G. E. (1998). *Learning in the Museum*. Routledge.

Hosey, G. R. (2000). Zoo animals and their human audiences: what is the visitor effect? *Animal Welfare*, 9, 343-357.

Hosey, G. R. (2005). How does the zoo environment affect the behaviour of captive primates? *Applied Animal Behaviour Science*, 90(2), 107-129.

The IUCN Red List of Threatened Species. Version 2017-1. <http://www. iucnredlist.org>. Date last accessed June 8, 2018.

Jensen, E. (2011). *Learning about Animals, Science and Conservation at the Zoo: Large-scale survey-based evaluation of the educational impact of the ZSL London Zoo Formal Learning programme*. A report to The Zoological Society of London.

Jensen, E. (2014). Evaluating children's conservation biology learning at the zoo. *Conservation Biology*, 28(4), 1004-1011.

Jones, H., McGregor, P. K., Farmer, H. L. A. & Baker, K. R. (2016). The influence of visitor interaction on the behavior of captive crowned lemurs (*Eulemur coronatus*) and implications for welfare. *Zoo Biology*, 35(3), 222-227.

Kratochvil, H. & Schwammer, H. (1997). Reducing acoustic disturbances by aquarium visitors. *Zoo Biology*, 16, 349-353.

Martin, P. & Bateson, P. (2007). *Measuring behaviour: an introductory guide*. Cambridge University Press.

Merriam Webster Dictionary. https://www.merriam-webster.com/. Date last accessed August 31, 2018.

Moss, A. & Esson, M. (2013). The Educational Claims of Zoos: Where Do We Go from Here? *Zoo Biology*, 32(1), 13-18.

Moss, A., Esson, M. & Francis, D. (2010). Evaluation of a third-generation zoo exhibit in relation to visitor behavior and interpretation use. *Journal of Interpretation Research*, 15, *11–28.*

Moss, A., Jensen, E. & Gusset, M. (2015). Evaluating the contribution of zoos and aquariums to Aichi Biodiversity Target 1. *Conservation Biology*, 29(2), 537-544.

Mun, J. S. C., Kabilan, B., Alagappasamy, S. & Guha, B. (2013). Benefits of Naturalistic Free-Ranging Primate Displays and Implications for Increased Human–Primate Interactions. *Anthrozoös*, 26(1), 13-26.

Ogden, J. & Heimlich, J. E. (2009). Why focus on zoo and aquarium education? *Zoo Biology*, 28(5), 357–60.

Orams, M. B. & Hill, G. J. (1998). Controlling the ecotourist in a wild dolphin feeding program: is education the answer? *The Journal of Environmental Education*, 29(3), 33-38.

Ozella, L., Favaro, L., Carnovale, I. & Pessani, D. (2015). Pond Use by Captive African Penguins (*Spheniscus demersus*) in an Immersive Exhibit Adjacent to Human Bathers. *Journal of Applied Animal Welfare Science*, 18(3), 303-309.

Patrick, P. G., Matthews, C. E., Ayers, D. F. & Tunnicliffe, S. D. (2007). Conservation and Education: Prominent Themes in Zoo Mission Statements. *The Journal of Environmental Education*, 38(3), 53–59.

Patrick, P. G. & Tunnicliffe, S. D. (2013). *Zoo talk*. Springer Science & Business Media.

Price, E. C., Ashmore, L. A. & McGivern, A. M. (1994). Reactions of zoo visitors to free-ranging monkeys. *Zoo Biology*, 13(4), 355-373.

Ramsay, N. F. (1995). The influence of environmental constraints on aspects of the eco-ethology of the lemurs (*Lemur catta*) Linnaeus 1785 and (*Eulemur fulvus mayottensis*) Schlegel 1866 in wild and captive environments. [PhD Dissertation]. Cork: University College Cork.

Reade, L. S. & Waran N. K. (1996). The modern zoo: how do people perceive zoo animals? *Applied Animal Behaviour Science*, 47(1), 109-118.

Sauther, M. L., Sussman, R. W. & Gould, L. (1999). The socioecology of the ring-tailed lemur: thirty-five years of research. Evolutionary Anthropology Issues News and Reviews, 8(4), 120-132.

Sherwen, S. L., Magrath, M. J., Butler, K. L., Phillips, C. J. & Hemsworth, P. H. (2014). A multi-enclosure study investigating the behavioural response of meerkats to zoo visitors. *Applied Animal Behaviour Science*, 156, 70-77.

Sherwen, S. L., Magrath, M. J., Butler, K. L. & Hemsworth, P. H. (2015). Little penguins, *Eudyptula minor*, show increased avoidance, aggression and vigilance in response to zoo visitors. *Applied Animal Behaviour Science*, *168*, 71-76.

Skibins, J. C. & Powell, R. B. (2013). Conservation caring: Measuring the influence of zoo visitors' connection to wildlife on pro-conservation behaviors. *Zoo Biology*, 32(5), 528-540.

Smith, L., Broad, S. & Weiler, B. (2008). A closer examination of the impact of zoo visits on visitor behaviour. *Journal of Sustainable Tourism*, 16(5), 544-562.

Species 360. https://www.species360.org/. Last date accessed August 22, 2018.

Swaisgood, R. R. & Shepherdson, D. J. (2005). Scientific approaches to enrichment and stereotypies in zoo animals: what's been done and where should we go next? *Zoo Biology*, 24(6), 499-518.

Tofield, S., Coll, R. K., Vyle, B. & Bolstad, R. (2003). Zoos as a source of free choice learning. *Research in Science & Technological Education*, 21(1), 67-99.

UNESCO. 1978. *Final report: Intergovernmental Conference on Environmental Education,* Organizedby UNESCO in Cooperation with UNEP, Tbilisi, USSR, October 14–26, 1977, Paris: UNESCO ED/MD/49.

Wagoner, B. & Jensen, E. (2010). Science learning at the zoo: Evaluating children's developing understanding of animals and their habitats. *Psychology & Society*, 3(1), 65-76.

Wellington, J. & Szczerbinski, M. (2007). *Research methods for the social sciences*. Continuum International Publishing Group: London and New York.

Woolway, E. E. & Goodenough, A. E. (2017). Effects of visitor numbers on captive European red squirrels (*Sciurus vulgaris*) and impacts on visitor experience. *Zoo Biology*, 36(2), 112-119.

Chapter 2

Literature review

2.1 Educational research

Free-choice learning in the informal setting

Science education is continuously evolving and is not limited to the classroom, with the public generally learning science in both formal and informal settings (Falk, 2001; Phipps, 2010). It is a varied discipline which encompasses everything, for example, from secondary school students learning chemistry in a science laboratory for a state exam, to an adult continuing education class participating in a field trip to the rocky shore with learning outcomes expected to adhere to a certain curriculum, to primary school children visiting a science museum on a school tour in a free-choice learning experience. Regardless of the type of education programme followed, the goal of science education remains the same – to educate students and members of the public about science and the scientific process. Because of the broad and varied curriculum surrounding science education, this review has been narrowed to the area most relevant to the research, namely informal science education (see definition below), specifically with regard to aquariums and zoos.

Most students consider learning outside the classroom as an exciting and memorable way to learn, and learning outdoors has been part of school curriculum for many centuries (Braund and Reiss, 2004). Evidence of outdoor science education can be traced from the teachings of Johann Comenius in the early 17th century (Braund and Reiss, 2004). However, it is a broad and diverse area that can be difficult to define. Not only does the literature in the field of learning science outside the classroom have an extensive range, but there is also diverse terminology associated with the area (Carleton-Hug and Hug, 2010). Often the terms informal science education, free-choice learning, learning for fun, flexible learning and learning outside the classroom are used interchangeably. For this review, in keeping with the work of Ballantyne and Packer (2005), definitions of 'free-choice learning' and 'informal setting' are taken from Falk and Dierking's (1998) work where 'informal' refers to settings outside the classroom, such as in a science museum or zoo, and 'free-choice' means learning that is guided by the interest of the learner. Braund and Reiss (2004) caution that, depending on school requirements, children may not necessarily be given much 'choice' about learning in an outdoor environment. However, this study considers that the broader interpretation of free-choice learning encompasses learning in the zoo (Tofield et al., 2003). Falk (2001, p. 6) further refined these definitions to mean that free-choice learning is the type of learning that takes place in an informal setting, 'free-choice learning refers to the type of learning typically facilitated by museums, science centres, a wide range of community-based organizations, and print and electronic media including the internet.'

Science is a discipline that is conducive to learning outside the classroom, and there are many institutions that cater for informal science education experiences (Falk, 2001). It is generally accepted that the public visit science centres for a combination of curiosity, entertainment and educational reasons (Falk, 2001). Yet, what and how people learn at these venues is personal and varies considerably. The traditional theory that learning is a linear process, during which the learner accumulates knowledge as they experience an educational event, otherwise known as the transmission-absorption model of learning (Hein, 1998), is largely outdated. Particularly in an informal setting, where many factors are known to influence learning (Roschelle, 1995; Hein, 1998; Falk and Dierking, 2000; Phipps, 2010).

Opposed to the transmission-absorption theory of learning is constructivism, or the belief that learning is based on the construction of knowledge, and that importantly the learner is an active participant in the acquisition of knowledge (Hein, 1998). Thus, the present theory on the learning process or the framework surrounding informal science education is based on constructivism (Piaget, 1951; Vygotsky, 1978), particularly in the last twenty years (Phipps, 2010). Roschelle (1995) summarised the classical works of Dewey, Vygotsky and Piaget to explain the process of learning in an informal setting and concluded that prior knowledge, social relationships and communication are the essential components of learning during a new experience, such as at a museum. Ham (2009) also returns to the classical work of Freeman Tilden (1957), *Interpreting Our Heritage*, who was one of the first environmental educators to describe informal science education from a constructivist approach. Ham (2009, p. 51) summarises Tilden's work by stating 'that the main thing interpretation should aim to accomplish is provoking visitors to think for themselves. . . [and] find their own personal meanings and connections.' In summary, learning science in an informal setting is a highly personal, cumulative process, based on multiple prior experiences, which together contribute to the construction of knowledge (Roschelle, 1995; Hein, 1998; Falk, 2001; Ham, 2009).

Currently, the archetypal model for understanding free-choice learning in informal settings was developed by Falk and Dierking (2000) in their book *Learning from Museums*. Based on the constructivist theory of learning, it has formed the basis for understanding free-choice learning in other works, such as Braund and Reiss's *Learning Science Outside the Classroom* (2004), as well as the Ballantyne and Packer (2005) review on free-choice learning. Falk and Dierking (2000) describe three over-lapping areas: the personal (motivation, prior knowledge), the socio-cultural (interactions, conversations, expectations of others), and the physical (attraction of surroundings, excitement), which converge to shape the learning experience in an informal setting. However, the research undertaken in this study is guided not only by Falk and Dierking's theory, but it is also informed by more general work in the area of educational research (e.g. Cohen et al., 2007).

Adults' learning constitutes some of the major research undertaken in the area of informal science education (Adelman et al., 2000; Balmford et al., 2007; Falk and Storksdieck, 2010), and previous research (e.g. Adelman et al., 2000) has shown that positive learning outcomes have been achieved. Yet, learning is largely dependent on prior knowledge and motivation for the visit (Packer, 2006; Falk and Storksdieck, 2010). Not all research on adult visitors at informal learning centres has reported positive learning outcomes. For example, Balmford et al. (2007) reported little or no measurable effect from a single visit to a zoo on adults' conservation knowledge.

Additionally, it must be questioned which informal settings to consider for this thesis. For example, are the learning experiences at a science museum and a zoo comparable? Do results from one setting translate to a different setting? Carleton-Hug and Hug (2010) cite 'diversity of the field' as one of the challenges faced by environmental educators, with scholars ranging from areas as diverse as public health to conservation biology. Briseño-Garzón (2014) caution that learning experiences at zoos and aquariums may differ from those at other informal settings, and Milan and Wourms (1992) suggest that museum studies are not necessarily applicable to zoos. However, Bitgood (1992) states that researchers should neither be too cautious, nor too general, in applying interpretations from one type of setting in visitor research to another, but must carefully apply generalities from one situation to the next. Because there is little quantifiable data surrounding children's learning in the zoo, Bitgood's (1992) suggestion is followed in this review. Research from all informal education centres is cautiously considered when applicable, while remembering that zoos and aquariums are distinct from other settings because of the presence of live captive animals. Therefore, to define and narrow the topic, this review will primarily focus on environmental and zoological education programmes involving children. However, certain authors (e.g. Falk and Ballantyne) have made such significant contributions to the area of informal science, in settings other than zoos, that their works are frequently referenced.

Environmental education research

As educational theory has advanced, from the transmission-absorption theory to the constructivist theory, so too have the goals of environmental education evolved. It is no longer sufficient for educators to simply supply their visitors with facts and assume that this will result in behaviour change. Now environmental education centres are expected to follow the goals outlined by the Tbilisi Declaration (UNESCO, 1978), which includes the development of new pro-environmental behaviour patterns in visitors as an expected learning outcome (Ogden and Heimlich, 2009). Hungerford and Volk (1990) reinforced this goal in a seminal paper presented at a UN sponsored conference, where they stated that the goal of environmental education should be responsible citizen behaviour. This can be achieved by changing the teaching process from focusing on knowledge and awareness to empowerment and ownership of environmental issues, which makes environmental issues personal (Hungerford and Volk, 1990).

When reviewing attitude and behaviour change in environmental education programmes, Ballantyne and Packer (2005) consider Ajzen's (1985) Theory of Planned Behaviour. In summary, Ajzen (1985; 1991) stated that behaviour is a result of three categories of salient beliefs: behavioural (beliefs and attitudes relating to the consequences of a behaviour), normative (beliefs about social pressure to engage in a behaviour) and control beliefs (beliefs about the ability to perform or control a behaviour). When educators plan environmental interpretation designed to result in behaviour change, they must consider which of these beliefs their curriculum aims to challenge, change or promote (Ballantyne and Packer, 2005). When done successfully, this can result in significant impacts on learning outcomes (Ham and Krumpe, 1996; Ballantyne and Packer, 2005; Ballantyne and Hughes, 2006). Additionally, Ballantyne et al. (2011) further explain conservation related behaviour change, as a four-step sequential process which evolves from sensory impressions to emotional affinity to reflective response and ultimately behavioural response. However, in order to truly change behaviour, more research is needed to understand why some people engage in undesirable behaviour (e.g. littering) and thus identify the underlying beliefs that may cause the negative behaviour (Smith et al., 2008).

Kola-Olusanya (2005) offers a summary of outdoor learning during childhood. The early years are characterised as a time of exploration and discovery; the middle years are defined by greater assimilation of knowledge and understanding of nature by direct and indirect experience, a greater sense of awareness for other creatures may develop; late childhood is a time of ‘daring exploration’ of the natural world when a child might develop interests and skills to last a lifetime (Kola-Olusanya, p. 303). Childhood is an essential period for developing affection for the natural world (Myers and Saunders, 2002), which seems to be best achieved through direct contact and experience with nature (Kola-Olusanya, 2005). Anderson (2003) warns that if children are not introduced to nature at an early age, their attitude toward conservation may not be positive later in life. The free-choice learning that takes place in informal science settings plays a fundamental role in children’s learning, understanding and appreciation of environmental issues (Kola-Olusanya, 2005).

Indeed, world-wide research suggests that outdoor learning benefits children, not only in terms of learning outcomes and knowledge gain, but also in positive attitudinal and behavioural changes (Palmberg and Kuru, 2000; Ballantyne et al., 2001; Ballantyne and Packer, 2002; Kola-Olusanya, 2005; Dillon et al., 2006). Ballantyne and Packer (2002) confirm through the use of pre- and post-questionnaires that learning outside the classroom at an environmental education programme is appealing to primary and secondary school students (aged 8-17). It promotes positive environmental attitudes and behaviours, with both age groups showing an interest in learning about the environment and wildlife in particular (Ballantyne and Packer, 2002). Falk and Balling (1982) also report significant learning for student groups (3rd and 5th class) who were evaluated at either a field trip to a nature centre or a short, outside of the classroom (on school grounds) activity; however, behaviour varied with age and setting.

Yet, it is not surprising that many factors are reported to influence learning outcomes. Teacher preparedness, prior knowledge, novelty of experience, first hand interaction with wildlife, emotional connection, follow-up work and even characteristics of the interpreter are all cited as contributing to learning (Falk and Balling, 1982; Palmberg and Kuru, 2000; Ballantyne et al., 2001; Ballantyne and Packer, 2002; Dillon et al., 2006; Stern and Powell, 2013). Advanced preparation and prior knowledge appear to have a significant impact on learning outcomes. Palmberg and Kuru (2000) found that children (11 and 12 years old) with prior experience of outdoor activities appear to have a stronger and more empathic relationship to nature than those who did not have prior experience. Ballantyne and Packer (2002) state that providing students with pre- and post-classroom activities may help build students anticipation for the visit, as well as allowing more freedom during the trip, if the more intellectual learning has already taken place. This is similar to findings of studies on adults, with the importance of previous knowledge, experience and motivation for the visit a consistent theme in Falk's research (Falk, 2001; Falk et al., 2007; Falk and Stoksdieck, 2010). However, children may not choose to visit the site, but rather it is chosen for them by parents and teachers. Thus, motivation for the visit may not be as significant a factor for children's learning as it is for adults.

Novelty of the experience also affects learning on a field trip. Ballantyne and Packer (2002) found that students who had not previously visited the site were more excited about the visit than those who had visited the site. Though excitement over the field trip can interfere with learning, especially for younger children (Falk and Balling, 1982), emotional content of the visit and direct interaction with wildlife also generate positive outcomes and are associated with attitudinal and behavioural change (Ballantyne et al., 2001; Ballantyne and Packer, 2002, 2005; Luebke et al., 2016). Ballantyne and Packer (2002) report that observing wildlife in a natural environment stimulates students' empathy. Specifically, seeing an animal injured (or in difficulty) due to human activities, such as pollution, provoked a strong emotive response from students and this was cited by students as eliciting changes in their behaviour and attitudes (Ballantyne et al., 2001). Follow-up work, after an outdoor learning experience has taken place, can reinforce learning (Ballantyne and Uzzell, 1994; Dillon et al., 2006), and some studies that have found learning to be absent, limited or short-term, cite lack of follow-up activity and reinforcement as contributory factors (Adelman et al., 2000; Ballantyne and Packer, 2005; Balmford et al., 2007; Kuhar et al., 2010).

Yet, learning outcomes for free-choice environmental education programmes can be difficult to recognise (Stroksdieck et al., 2005). A brief educational intervention in an informal setting may not stimulate profound learning or behaviour change; however, learning can still occur in other and sometimes unexpected areas (Storksdieck et al., 2005). Incidental learning (relating to the overall experience), general learning, or reaffirmation of previously held beliefs may occur and these should be considered valid learning outcomes (Storksdieck et al., 2005). One such area is students' interest in science. Because outdoor learning has been shown to promote positive attitudes toward the environment, and since it is known that children's attitude toward science tends to decline from age 12 (Bennett, 2001; Osborne et al., 2003), it is possible that informal science education, such as a trip to the zoo, is a way to increase interest in science. According to Whitehouse et al. (2014), interactive devices at animal exhibits at zoos have been effective at increasing general interest in science. Equally, learning may not be immediately apparent after the first visit (Adelman et al., 2000; Balmford et al., 2007). For this reason, long-term measures of learning and behaviour change should be undertaken several months post-visit, to evaluate if learning persists or develops more intensely over time (Ballantyne et al., 2007; Jensen et al., 2017).

Zoological education

As previously discussed, there is not necessarily a clear divide between informal science education, environmental education and zoological education. In addition, the educational theories behind learning in different informal sites are similar, making disentangling the different learning experiences challenging. However, since this research takes place in a wildlife park and an aquarium and so little is known about education in these settings, it was decided to focus on the most relevant zoo-based studies here. Additionally, and for the remainder of the study, zoo, wildlife park and aquarium are considered sufficiently similar (because of the presence of visitors and live animals) to be referred to collectively as 'zoo' when appropriate (Skibins and Powell, 2013). Tofield et al. (2003) specifically examined the usefulness of zoos as free-choice educators and concluded that the experience of learning science at the zoo is limited for the general public. However, there is evidence, such as a better understanding of animal welfare and exhibit design, that learning does occur for primary school students, this can be augmented with pre- and post-visit activities and better connections to the school curriculum (Tofield et al., 2003).

Most zoos list educating their visitors as one of their main goals (Hosey, 2005; Patrick et al., 2007; Fernandez et al., 2009; British and Irish Association of Zoos and Aquariums (BIAZA), 2018); yet, education is one of the least understood influences within the zoo (Reade and Waran, 1996; Fernandez et al., 2009). Zoos use many forms of interpretation to communicate educational messages to the public, ranging from signs to guided tours (Moscardo et al., 2004), and educational material is a regular presence in the zoo (Anderson, 2003). However, recently zoos have been asked to offer evidence of their claims that they are indeed educators, as thus far there has been only limited peer-reviewed research that shows learning as an outcome of a zoo visit. As discussed by Jensen (2011, p. 5), the RSPCA (Royal Society for the Prevention of Cruelty to Animals) insinuated that zoos are not meeting 'the high burden of proof [of educational claims] to justify holding animals in captivity'. Jensen (2014) summarises that zoos are increasingly under pressure to demonstrate a positive educational impact at their facilities and more research is needed. Esson (2009, p.1) states that 'zoos are...between a rock and a hard place when it comes to substantiating claims to be education providers,' as thus far, the literature on zoological education does not confirm the ambitious mission statements of zoos as education providers (Moss and Esson, 2013). Moss and Esson (2013), have called for research that explores all of the possible outcomes of zoo-based learning, including unexpected outcomes, negative outcomes, and those outcomes that are outside of the institutional goals, and only then will research provide an accurate picture of learning in zoos.

Yet, some limited research on education in the zoo has occurred (see Chapters 5 and 6 for more details of the relevant literature). Staff involvement, exhibit design, as well as interactive displays, have all been found to contribute to visitor learning and positive conservation action (Tofield et al., 2003; Lukas and Ross, 2005; Lindemann-Matthies and Kamer, 2006; Randler et al., 2007; Wagner et al., 2009). For example, a study at the National Aquarium in Baltimore (MD, USA) found that a visit to the aquarium positively influenced adult visitors' conservation awareness, experience and knowledge (Adelman et al., 2000). In 2007 the Association of Zoos and Aquariums (AZA) sponsored a study conducted by Falk et al. (2007), which found that learning does occur after a zoo or aquarium visit. However, this study was criticised by Marino et al. (2010) on the grounds of methodological validity. Even adults in family groups, who did not categorise themselves as learners, gained in the cognitive, social and affective domains after an aquarium visit, which may be attributed to group interactions and the experience of adults facilitating learning for children (Briseño-Garzón et al., 2007). More recently, a large-scale international evaluation study found that knowledge of biodiversity and knowledge of actions to protect biodiversity increased after a zoo or aquarium visit (Moss et al., 2015).

Studies involving children are more limited, but there is some evidence that learning does occur in the zoo for children (Tunnicliffe et al., 1997; Tunnicliffe, 2004; Jensen 2011, 2014) (see Chapters 5 and 6 for more detail). Additionally, studies implementing an educational intervention for visitors reported positive knowledge gain (Lindemann-Matthies and Kamer, 2006; Randler et al., 2007). Interpretive presentations (e.g. question and answer sessions, a mock training session and touching training tools) compared to fact-only presentations during animal training sessions resulted in increased knowledge gain in children (Visscher et al. 2009). However, like Falk and Dierking (2000), Wagoner and Jensen (2010) advise that learning in the zoo is a process that involves a combination of sources that accumulate over time, including formal education and the media, and that zoological education interacts with pre-existing ideas to develop a new understanding of animals. Wagoner and Jensen (2010) point out that researchers must continually remember that a failure to detect learning does not necessarily mean that learning has not occurred, but rather it is possible that the methodology used has failed to detect a specific learning outcome.

As with environmental education, the ultimate goal of zoological education should be action and behaviour change, not just awareness and knowledge gain (Ogden and Heimlich, 2009). Smith et al. (2008) considered conservation related behaviour change after adult visitors attended a birds of prey presentation. Researchers and zoo staff developed an interactive education programme about the birds of prey, which featured two specific conservation actions (recycling paper and picking up road kill). They found that 81% of the group surveyed on exiting the zoo could recall hearing information on conservation actions during the presentation, and perhaps most importantly 54% of respondents stated that they intended to commence or increase their commitment to the conservation actions described during the birds of prey programme (Smith et al., 2008). A follow-up survey six months later revealed that some visitors had followed through with intentions to start or increase the conservation related actions (Smith et al., 2008). While the study may demonstrate certain behaviour change, Smith et al. (2008) are quick to note that it is difficult to attribute subsequent change in behaviour directly to a zoo visit, as there could be many other influences present. Additionally, behaviour may revert back to initial levels over time (Adelman et al., 2000; Dierking et al., 2004; Smith et al., 2008). However, a relevant point that Smith et al. (2008) have established is that in order to influence a specific behaviour, messages about that specific behaviour should be communicated to visitors during their visit. Furthermore, it may be easier for researchers to measure observable, on-site (e.g. use of zoo recycling facilities) behaviours, rather than self-reported, off-site (e.g. picking up road kill) behaviours, though it is perhaps off-site behaviour change that represents the long-term goals of zoo (Smith et al., 2008). Smith (2009) concluded that zoos need to prioritise and effectively communicate which conservation related behaviours they aim to influence as a result of a zoo visit, whether they are on- or off-site behaviours and how to effectively evaluate the result.

An earlier study that investigated behaviour change in the zoo, manifested by visitors' willingness to return conservation solicitation cards, found that visitors who participated in an interactive experience with an elephant show and bio-fact program were more likely to take conservation related action (Swanagan, 2000). The author concluded that visitors need to form a personal connection to conservation issues in order to change behaviour. Recently, Skibins and Powell (2013) measured this personal connection termed 'conservation caring' (CC) (adopted from Rabb and Saunders, 2005) that visitors may develop for a specific animal as a result of an education programme, and then investigated the relationship between CC and conservation action after a zoo visit. A strong connection was found between CC and species-specific behaviour (e.g. adopting an animal), but not conservation related behaviours in general. This is in keeping with the results of the Swanagan (2000) study which found that visitors were willing to take action to support a specific animal which they had learned about during their interactive experience. Positive personal experiences with gorillas at the Bronx Zoo also lead to increased conservation concern (Hayward and Rothenberg, 2004). Most similar to the present study, Bexell et al. (2013) found that children who developed bonds with animals during a five-day camp were less likely to behave negatively during the camp, which is significant because unlike the previously mentioned studies the change in behaviour was almost immediate and measurable on-site.

Additionally, and unique to the zoo setting, the characteristics and 'attractiveness' of the animals, such as activity, size and presence of an infant, influences visitors' attitudes and learning experience, with visitors showing increased interest in large, exotic active mammals (Bitgood et al., 1988; Tofield et al., 2003; Moss and Esson, 2010; Albert et. al., 2018). It has even been suggested that zoos consider a species' educational value when planning exhibits (Moss and Esson, 2010; Collins et al., 2016). Charismatic Mega Fauna (CMF) have also been found to elicit a strong response from visitors and a positive connection to these animals is likely to occur, which could lead to enhanced learning outcomes (Skibins et al., 2013).

2.2 Zoo-based research

Exhibit design

The concept that the zoo environment, and exhibit design in particular, influences visitors' perceptions of animals and learning is supported by several early studies. The general consensus being that wild animals and naturalistic enclosures command more respect and better attitudes from the public than sterile cage-like exhibits (Coe, 1985, 1996; Bitgood et al., 1988; Finlay et al., 1988; Shettel-Neuber, 1988; Reade and Waran, 1996), which can lead to disrespect and indifference towards animals (Sommer, 1972). Naturalistic enclosures positively influence the visitor experience in zoos even if they make the animals less visible (Davey, 2006a), though the preference for naturalistic enclosures may be more apparent in younger visitors (Tofield et al., 2003). Tofield et al. (2003), Davey (2006a) and Moss et al. (2010) all confirm that visitors spent longer at and prefer to see animals in enriched third-generation exhibits rather than sterile concrete first- or second-generation exhibits, and they possibly learn more during their visit due to increased appreciation for the animals and opportunities to see more natural behaviour.

While cage design in zoos has changed dramatically over the last 100 years (Moss et al., 2010), perhaps the ultimate way of keeping animals in captivity is the free-range environment. Here a gap in the literature exists, not only in terms of visitor experience, but also in terms of animal welfare. Free-ranging zoo animals have the opportunity to control their contact with visitors and retreat from visitors if necessary, which is essential in mitigating visitor induced stress (Carlstead and Shepherdson, 2000; Hosey, 2000; Davey, 2007; Morgan and Tromburg, 2007), but paradoxically they are potentially exposed to more intense interactions with the public (Mun et al., 2013). See Chapter 3 of this thesis for further discussion on free-ranging animals.

Visitor effects

The field of visitor studies is a comprehensive area of research that focuses on people as they visit, for example, museums or even commercial visitor attractions like amusement parks. Investigations in the area of visitor studies may include mapping or tracking visitor movement through different exhibitions (Davey, 2006b). While similarities exist between visitors in museums and zoos, an added complexity in the zoo setting is the visitors' ability (both intentionally and unintentionally) to affect the behaviour of the animals living within the zoo. This has given rise to the area of visitor effects, which may be summarised by saying that zoo animals may find visitors either stressful, enriching or of no consequence (Hosey, 2000). As a broad generalisation, much of the research has focused on primates and the effect of visitors has been found to be a stressful one to these animals (see Hosey 2000; 2005 for summary). See Chapter 3 for further discussion on visitor effects in primates.

In contrast to primates, previous research on visitor effects in birds presents a largely neutral or positive influence. A long-billed corella (*Cacatua tenuirostris*) appeared to seek interaction with visitors; however, it was also observed that the bird sometimes retreated to the back of his cage when the zoo was very busy (Nimon and Dalziel, 1992). Similarly, Collins and Marples (2015) discovered that citron-crested cockatoos (*Cacatua sulphurea citrino cristata*) did not retreat from visitors and even became more social in their presence. The authors conclude that in moderation visitors could be seen as a type of enrichment because when visitors were present the birds engaged in more species-typical behaviour. When visitors were allowed to swim adjacent to African penguins (*Spheniscus demersus*), pond use by penguins was initially reduced, but over time the penguins appeared to habituate to the presence of the bathers (Ozella et al., 2015a). Furthermore, the daily presence of visitors at the exhibit appeared to have no effect on physiological stress in this penguin group (Ozella et al., 2015b), though it is possible that a behavioural effect occurred which was not detected by the physiological measures used in the study.

Not all of the research on visitor effects has focused on primates or birds. A recent study found that as the number of visitors increased, harbour seals (*Phoca vitulina*) were more often submerged in their pool (Stevens et al., 2013), though the welfare implications of these studies are not clear. Margulis et al. (2003) and O'Donovan et al. (1993) both report no effect of visitors on various species of cat behaviour in captivity, though Mallapur and Chellam (2002) found that the activity level of Indian leopards (*Panthera pardus*) was influenced by visitors. Captive European red squirrels (*Sciurus vulgaris*) were studied in a walk-through enclosure and it was found that more interactions occurred when more visitors were present, but the squirrels' behavioural response to visitors varied based on visitors' age (Woolway and Goodenough, 2017). When more children were present, feeding decreased and locomotion increased, but when more adults were present, feeding increased and inactivity decreased, ultimately the authors concluded that excessive noise and movement in the enclosure should be minimised (Woolway and Goodenough, 2017). Interestingly, according to Haigh et al. (2017) wild red squirrels at Fota Wildlife Park also responded to visitors. Generally, squirrels were only observed to utilise the public areas of the park when it was closed to visitors. Furthermore, high levels of faecal cortisol metabolites (FCM), potentially indicative of stress, corresponded to squirrels tested in areas where human disturbance was greatest. However, no overall correlation between the number of visitors present and stress levels in squirrels was detected (Haigh et al., 2017).

Visitors' behaviour and noise level while viewing animals is a contributory factor to their overall effect on several species of animals' behaviour, but this is an area of sparse literature. An active, aggressive crowd may have a more damaging effect than a passive, respectful one. It was observed, but not quantified, by Birke (2002) that a male orang-utan banged and called more when human male visitors stared for prolonged periods. Wood (1998) found that when visitors viewed chimpanzees with one day old enrichment, they were more likely to engage in negative behaviours like banging, throwing objects and shouting at the animals. This coincided with a period when the primates were more likely to be grooming, playing, visually scanning or engaging in aberrant behaviour than foraging or using objects (Wood, 1998). When visitors stared or yawned at Siamang gibbons (*Hylobates syndactylus*), the primates were more aggressive (Nimon and Dalziel, 1992). Additionally, sound pressure levels in zoos have been found to be much higher than in wild habitats, and there is evidence that some zoo-housed animals may react to elevated sound levels with increased vigilance, heart rate and agitation (Morgan and Tromborg, 2007). Recently, Quadros et al. (2014) investigated the effect of visitor noise on range of 12 different mammal species in captivity and found that there was no overall effect of noise, but that some species became more vigilant and active when noise increased. A recent study on captive koalas (*Phascolarctos cinereus*) reported that koalas were more vigilant when visitors were noisy (Larsen et al., 2014).

Visitor effects in captive animals may also vary with enclosure type (Hosey, 2005). Generally, it is thought that more naturalistic enclosures reduce negative visitor effects

(Blaney and Wells, 2004; Hosey, 2005; Davey, 2007; Fernandez et al., 2009; Ozella et al., 2015b). See Chapter 3 of this thesis for further discussion. At Fota Wildlife, few effects of visitors on the free-ranging animals have been discovered. According to Forde (2006), no significant difference in behaviour was found for either free-ranging Eastern Grey Kangaroos (*Macropus giganteus*) or Maras (*Dolichotis patagonum*) when visitors were or were not present. However, there was some indication, though not statistically significant that the kangaroos rested more when more visitors were present and that when no visitors were present other behaviours were observed more (Forde, 2006), but this could also be due to the time of day and not the lack of visitors. Ramsay (1995, p. 104), who studied the free-ranging ring-tailed lemurs at Fota Wildlife Park, concluded that overall the free-range method is a 'worthwhile system for keeping this …species in captivity.' The lack of negative behaviour observed in free-ranging animals when visitors are present, suggests that the free-range environment may be the optimal way for keeping certain species in captivity while simultaneously retaining visitor enjoyment. However, it is an area of limited research, and the possibility of intense animal-visitor interaction that accompanies the free-range environment, makes this an area that warrants further investigation.

Human-animal interactions (HAIs) in the zoo setting

The very fact that an animal is housed in a zoo or aquarium implies that to some degree it will come into contact with humans, but the extent of contact and the effect that it might have on the animal varies considerably based on, for example, exhibit design (Hosey, 2005). Similar to Hosey (2008), the definition of interaction used by Hinde (1976) to describe inter-personal relationships has been adopted for this research. Thus, a human-animal interaction (HAI) means an individual shows a behaviour to another individual who may or may not respond, in time this could lead to the establishment of a human-animal relationship (HAR) (Hosey, 2008). See Chapter 3 of this thesis for more detail on HAIs, HARs, human-animal bonds (HABs) in the zoo and specific animal-visitor interactions with primates.

Visitor experiences involving animal-visitor interactions have become more prevalent in zoos. These are often marketed as enriching for the animals, educational for the visitors and beneficial for the zoo in financial terms, yet little research exists to verify these assertions (Jones et al., 2016). A small study on a visitor feeding experience with ring-tailed lemurs (*Lemur catta*) and Humboldt penguins (*Spheniscus humboldti*) found that lemurs were more vigilant, but less aggressive during the feeding experiences (Buss and Baker, 2013). The authors conclude that there is an overall neutral effect of the feeding experience on the lemurs, suggesting that the lemurs may be an important species for promoting positive conservation attitudes and behaviours in visitors (Buss and Baker, 2013). Humboldt penguins appeared to rest less and preen more during the feeding experience. The authors acknowledge that this is an ambiguous result, but saw no other indication of stress and conclude that penguins too may be a useful flagship species (Buss and Baker, 2013). Large felids responded to interactive visitor experiences (both protected and hands-on) with changes in behaviour, generally involving active, inactive, feeding and pacing behaviours (Szokalski et al., 2013). The authors state that more research is needed, but there was no evidence of reduced welfare in the cats used in the interactive experiences. Though distinctly different from general zoo animals, research on domestic or semi-domestic animals at a petting zoo, revealed that while behavioural changes did occur while visitors were present, there was no indication of reduced welfare in the petting zoo animals even when visitors groomed the animals (nor was this found to be enriching for the animals), again response varied based on species type (Farrand et al., 2014).

Aquariums also offer animal-visitor interactions, often in the form of ‘touch-tanks,’ and though it has been shown that children learn more, especially in the affective or emotional domain, from live specimens (Sherwood et al., 1989), little is known about how the animals react to being touched by visitors. ‘Swim with an animal’ programmes are gaining in popularity both in the wild and at aquariums. At Marineland in Napier, New Zealand, three captive female dolphins (*Delphinus delphis*) were monitored before, during and after a ‘swim-with-dolphin’ programme. It was found that the dolphins used their refuge area significantly more when swimmers were in their pool, but use of the area returned to pre-session levels 15 minutes after the visitor swim (Kyngdon et al., 2003). The dolphins also displayed different behaviour during the swim than before or after it, touching and surfacing increased, while aggressive, submissive, ‘abrupt’ and play decreased during the swimming session. Yet, the authors conclude that overall the dolphins have habituated to the swimmers and their welfare was not affected by the presence of the swimmers (Kyngdon et al., 2003). Animals can also be exposed to intense visitor interactions as part of a zoo education programme. Baird et al. (2016) investigated the welfare of ‘program’ animals in the zoo using behavioural and physiological measures. Results showed that no difference in behaviour or faecal glucocorticoid metabolites (FGM) (raised levels of FGM are potentially indicative of stress) between armadillos that were used for education programmes, armadillos that were off-exhibit and armadillos that were on exhibit. Additionally, the authors discovered no effect (FGM and behaviour) of handling as part of an education programme in armadillos, hedgehogs and red-tailed hawks. However, the overall amount of handling, including husbandry, was associated with raised FGM and increases in certain behaviours, including undesirable behaviours, though length of handling, enclosure size and substrate were also contributory variables (Baird et al., 2016). Of course, there are other venues, like eco-tourist attractions (Ballantyne and Hughes, 2006) and farms where animals experience intense interactions with humans but reviewing these in detail is out of the scope of the current research.

Reports of negative HAIs in the zoo are rare, probably because of strict zoo management guidelines, but also possibly due to existing positive HARs (Hosey and Melfi, 2015). When negative HAIs do occur, they are more likely to involve staff than visitors, though zoo visitors have also been subjected to aggressive animal attacks (Hosey and Melfi, 2015). The latter can be serious or even fatal, and might in part be attributable to unusual circumstances, the absence of established HARs or previous negative HARs (Hosey and Melfi, 2015). Yet, not all animals react negatively towards visitors, even when the interactions are frequent or intense. It is even suggested that sometimes these relationships can be enriching for captive animals (Claxton, 2011). Much of the research in this area reports some limited behavioural response, which researchers have generally interpreted as neutral to animal welfare. However, it should not be overlooked that subtle behavioural or physiological changes that might indicate reduced welfare have not been detected. Further work is needed in the area, especially since animal-visitor interactive experiences are becoming more prevalent in zoos.

Enrichment

Another way of promoting visitor learning and reducing negative visitor effects is through provisioning captive animals with environmental enrichment. Environmental enrichment is a well-established practice used by zoos to improve both the physiological and psychological welfare of captive animals by providing them with environmental stimuli

(Swaisgood and Shepherdson, 2005). This can also include providing captive animals with a naturalistic or enriched enclosure. One of the major goals of enrichment is to promote species typical behaviour in captivity and reduce stress by offering captive animals increased behavioural choices (Carlstead and Shepherdson, 2000). Enrichment has been successful in reducing stereotypical behaviour in carnivores, primates and other species in captivity by 50-60% (Swaisgood and Shepherdson, 2006).

Environmental enrichment has been classified as either extrinsic, which generally involves a food-based reward, or intrinsic, where the behaviour elicited by the enrichment, such as exploration, is the desired outcome (Tarou and Bashaw, 2007; Damasceno et al., 2017). More traditionally, enrichment has been divided into the following categories: food-based, sensory, structural or physical, social, cognitive and temporal (Carlstead and Shepherdson, 2000; Young, 2003; Quirke, 2011). In order to make positive contributions to the growing field of environmental enrichment, it is imperative for researchers and zoo staff to follow a procedure for the implementation of enrichment so as to properly record and assess the outcome. The current research has followed the SPIDER framework which includes: setting goals, planning, implementing, documenting, evaluating and readjusting (Mellen and MacPhee, 2001).

While the general purpose of enrichment is to improve animal welfare, Tofield et al. (2003) summarises that zoos use enrichment for a variety of reasons including making zoo visits more enjoyable for visitors. Increased animal activity is often a consequence of enrichment. Several studies have confirmed that zoo visitors show more interest in and learn more from active animals (Bitgood et al., 1988; Anderson et al., 2003; Margulis et al., 2003; Davey et al., 2005; Moss and Esson, 2010), especially when the animals were engaged in species-specific behaviour (Altman, 1998). Zoo visitors were more aware of the positive impact of environmental enrichment on zoo animals than the general public, even though the general public were concerned that captive animals were bored (Reade and Waran, 1996). Though there has been limited further research to confirm visitors' perception of enrichment, ideally visitor experience, as well as animal welfare and zoo staff should be considered when implementing enrichment programmes (Tofield, et al., 2003; Davey et al., 2005). Zoo visitors often complain that animals are inactive or not visible, and enrichment may help increase activity and visibility (Anderson et al., 2003; Dutra and Young, 2015), though this must be carefully managed by zoos because animals may be more difficult to see in naturalistic enclosures (Davey, 2006a). However, one study that used enrichment, during zoo opening hours, in an attempt to encourage crepuscular Brazilian tapirs (*Tapirus terrestris*) to spend more time on view to the public, found that the presence of enrichment did not increase the amount of time that the tapirs were visible to the public (Dutra and Young, 2015). This approach may have been more successful with a diurnal species.

Additionally, several studies have used environmental enrichment, not only to increase animal activity and visibility, but also in an attempt to mitigate negative visitor effects. Carder and Semple (2008) examined the impact of feeding enrichment on visitor effects in relation to two specific behaviours in gorillas. At one of their study sites they found a positive association between visitor number and the duration of self-scratching and visual monitoring, during periods when the feeding enrichment was absent. In contrast, during periods of feeding enrichment, there was no significant association between visitor number and duration of either behaviour. This suggests that gorilla anxiety during periods of high visitor density may have been reduced with the provision of feeding enrichment at one of their study sites; however visitor numbers were higher during periods when the feeding enrichment was absent, and this may account for the gorillas' raised anxiety levels during this treatment. Clarke et al. (2012) also found that feeding enrichment and privacy screens decreased negative visitor effects, particularly in relation to reduced feeding. Birke (2002) achieved similar results, by providing orangutans (*Pongo pygmaeus*) with browse; activity and foraging increased, though the orangutans still covered their heads with sacks more when visitors were noisy. Similarly, Wood (1998) discovered that chimpanzees (*Pan troglodytes*) foraged and played more when enrichment was provided. Additionally, visitors enjoyed seeing chimpanzees with enrichment and commented on it 'suggest[ing] an intellectual curiosity of zoo visitors concerning what exactly the chimpanzees were doing with enrichment and a willingness to monitor the action closely,' though the increase in positive animal behaviour was not observed when the largest crowds were present (Wood, 1998; p. 225).

These studies confirm that environmental enrichment may be successful at positively influencing an animal's activity budget and visitors' interest. They also suggest that enrichment may be helpful at reducing negative visitor effects, though the benefits of this are not entirely clear and are probably dependent on other variables, such as species type and enclosure design. The delicate balance between captive animals and zoo visitors may be facilitated by the use of enrichment, which benefits not only the animals, but also the visitors, who may learn more and enjoy seeing more active animals. The relationship between enrichment, captive animals and zoo visitors warrants further investigation.

2.3 Conclusions

It is in the best interest of the zoo, in terms of animal welfare and also visitor enjoyment, that animals are content and not displaying negative, aggressive or stereotypic behaviours indicative of stress, yet these are the very behaviours that can occur when large, active crowds of visitors are present (Hosey, 2000, 2005). For example, social behaviour in chimpanzees, which visitors enjoy and imparts an important educational message, was reduced when large groups were present (Wood, 1998). This presents something of a conundrum for zoos. Positive perceptions of zoo animals are more likely to lead to greater empathy towards animals and greater support of conservation efforts (Hosey, 2005; Fernandez et al., 2009), which in turn might influence visitors' willingness toward financial support (Swanagan, 2000). Since zoos rely heavily on visitors for financial support, limiting visitors or constructing enclosures in such a way that animals are hard to see is not feasible, if zoos aim to please their supporters (Hosey, 2005; Fernandez et al., 2009). There have been a limited number of studies that attempt to control negative visitor effects through physical means such as barriers, camouflage netting, signage, and sound dampening materials (Kratochvil and Schwammer, 1997; Keane, 2005; Blaney and Wells, 2004; Sherwen et al., 2014). However, while these may give temporary results; perhaps a longer-term, financially more viable way to control negative visitor effects could be through enrichment and visitor education (Fernandez et al., 2009; Hosey, 2013; Quadros et al., 2014).

Previous work has shown that connections exist between enclosure design and visitor education (Coe, 1996; Moss et al., 2010), education and reduction of negative visitor behaviour (Orams and Hill, 1998; Bexell et al., 2013), enrichment and reduced negative visitor effects (Wood, 1998; Birke, 2002) or increased visitor interest (Davey et al., 2005), and more recently on visitor emotion and behaviour (Myers et al., 2004; Luebke and Matiasek, 2013; Luebke et al., 2016). However, to date, no published study has investigated the inter-relationship between education, visitors and animal behaviour in different zoo environments. The present study investigates the connections between these three things in a free-range environment, a naturalistic enclosure and a more traditional type of zoo enclosure. Despite zoos' stated enthusiasm for education and indications for further research, up until now, there has been a lack of this type of study in zoos, aquariums and wildlife parks in Ireland and the UK, and a limited understanding of the links between these influences in the zoo.

2.4 References

Adelman, L. S., Falk, J. H. & James, S. (2000). Assessing the National Aquarium in Baltimore's impact on visitors' conservation knowledge, attitude and behaviour. *Curator*, 43(1), 33-61.

Ajzen, I. (1985). From intentions to actions: A theory of planned behavior. In *Action control* (pp. 11-39). Springer Berlin Heidelberg.

Ajzen, I. (1991). The theory of planned behavior. *Organizational behavior and human decision processes*, 50(2), 179-211.

Albert, C., Luque, G. M. & Courchamp, F. (2018). The twenty most charismatic species.

PLoS one, 13(7), p. e0199149.

Altman, J. D. (1998). Animal activity and visitor learning at the zoo. *Anthrozoös*, 11(1), 12-21.

Anderson, L. L. (2003). Zoo education: from formal school programmes to exhibit design and interpretation. *International Zoo Yearbook*, 38, 75-81.

Anderson, U. S., Kelling, A. S., Pressley-Keough, R., Bloomsmith, M. A. & Maple, T. L. (2003). Enhancing the zoo visitor's experience by public animal training and oral interpretation at an otter exhibit. *Environment and Behavior*, 35(6), 826-841.

Baird, B. A., Kuhar, C. W., Lukas, K. E., Amendolagine, L. A., Fuller, G. A., Nemet, J., Willis, M. & Schook, M. W. (2016). Program animal welfare: Using behavioral and physiological measures to assess the well-being of animals used for education programs in zoos. *Applied Animal Behaviour Science*, 176, 150-162.

Ballantyne, R., Fien, J. & Packer, J. (2001). School Environmental Education Programme Impacts upon Student and Family Learning: A case study analysis. *Environmental Education Research*, 7(1), 23-37.

Ballantyne, R. & Hughes, K. (2006). Using front-end and formative evaluation to design and test persuasive bird feeding warning signs. *Tourism Management*, 27(2), 235-246.

Ballantyne, R., Packer, J., Hughes, K. & Dierking, L. (2007). Conservation learning in wildlife tourism settings: Lessons from research in zoos and aquariums. *Environmental Education Research*, 13(3), 367-383.

Ballantyne, R. & Packer, J. (2002). Nature-based excursions: School students' perceptions of learning in natural environments. *International Research in Geographical and Environmental Education*, 11(3), 218–236.

Ballantyne, R. & Packer, J. (2005). Promoting environmentally sustainable attitudes and behaviour through free-choice learning experiences: what is the state of the game? *Environmental Education Research*, 11(3), 281–295.

Ballantyne, R., Packer, J. & Sutherland, L. A. (2011). Visitors' memories of wildlife tourism: Implications for the design of powerful interpretive experiences. *Tourism Management*, 32(4), 770-779.

Ballantyne, R. & Uzzell, D. (1994). A checklist for the critical evaluation of informal environmental learning experiences. *International Journal of Environmental Education and Information*, 13(2), 111-124.

Balmford, A., Leader-Williams, N., Mace, G., Manica, A., Walter, O., West, C. & Zimmermand, A. (2007). Message received? Quantifying the impact of informal conservation education on adults visiting UK Zoos. *Catalysts for Conservation: a direction for zoos in the 21st Century*. In: Zimmermann A, Hatchwell M, Dickie L, West C. (Eds). *Zoos in the 21st century: catalysts for conservation?* Cambridge: Cambridge University Press. 120-136.

Bennett, J. (2001). Science with attitude: the perennial issue of pupils' responses to science. *School Science Review*. 82(300), 59-66.

Bexell, S. M., Jarrett, O. S. & Ping, X. (2013). The effects of a summer camp program in China on children's knowledge, attitudes, and behaviors toward animals: A model for conservation education. *Visitor Studies*, 16(1), 59-81.

Birke, L. (2002). Effects of browse, human visitors, and noise on the behaviour of captive orang-utans. *Animal Welfare*, 11, 189-202.

Bitgood, S. (1992). Does Audience Research From Museums Apply to Zoos? *Curator*, 35(3), 166–169.

Bitgood, S., Paterson, D. & Benefield, A. (1988). Exhibit design and visitor behaviour: empirical relationships. *Environment and Behavior*, 20, 474-491.

Blaney, E. C. & Wells, D. L. (2004). The influence of a camouflage net barrier on the behaviour, welfare and public perceptions of zoo-housed gorillas. *Animal Welfare*, 13(2), 111-118.

Braund, M. & Reiss, M. (2004). 'The nature of learning science outside the classroom.' In M. Braund and M. Reiss (eds), *Learning Science outside the classroom*. London: Routledge Falmer.

Briseño-Garzón, A. (2014). Defining informal settings through narrative of personal experience: aquariums as unique venues for learning. *Journal of Zoo and Aquarium Research*, *2*(4), 100-107.

Briseño-Garzón, A., Anderson, D. & Anderson, A. (2007). Adult learning experiences from an aquarium visit: The role of social interactions in family groups. *Curator: The Museum Journal*, 50(3), 299-318.

British and Irish Association of Zoos and Aquariums (BIAZA). (2018). Our Vision and Mission. https://biaza.org.uk/our-vision. Last date accessed: June 23, 2018.

Buss, D. & Baker, K. (2013). The effects of visitor feeding experiences in a captive zoo-housed environment: Are they enriching or not? Unpublished student report. Newquay Zoo, Cornwall, UK.

Carder, G. & Semple, S. (2008). Visitor effects on anxiety in two captive groups of western lowland gorillas. *Applied Animal Behaviour Science*, 115(3), 211-220.

Carleton-Hug, A. & Hug, J. W. (2010). Challenges and opportunities for evaluating environmental education programs. *Evaluation and Program Planning*, 33(2), 159-164.

Carlstead, K. & Shepherdson, D. (2000). Alleviating stress in zoo animals with environmental enrichment. In: G. P. Moberg & J. A. Mench (Eds.), *The biology of animal stress: Basic principles and implications for animal welfare*. CABI. p. 337-354

Clark, F. E., Fitzpatrick, M., Hartley, A., King, A. J., Lee, T., Routh, A., Walker, S. L. & George, K. (2012). Relationship between behavior, adrenal activity, and environment in zoo-housed western lowland gorillas (*Gorilla gorilla gorilla*). *Zoo Biology*, *31*(3), 306-321.

Claxton, A. M. (2011). The potential of the human–animal relationship as an environmental enrichment for the welfare of zoo-housed animals. *Applied Animal Behaviour Science*, 133(1), 1-10.

Coe, J. C. (1985). Design and perception: making the zoo experience real. *Zoo Biology*, 4(2), 197-208.

Coe, J. C. (1996). What's the message? Education through exhibit design. In: Wild Mammals in Captivity Principles and Techniques: Chapter 16, eds, D. Kleinman, M. Allen, K. Thompson, S. Lumpkin, H. Harris, University of Chicago Press. Chicago, Illinois.

Cohen, L. M. & Manion, L. l. & Morrison, K. (2007). *Research methods in education*, *6*. Routledge: London and New York.

Collins, C. K. & Marples, N. M. (2015). Zoo playgrounds: A source of enrichment or stress for a group of nearby cockatoos? A case study. *Journal of Applied Animal Welfare Science*, 18(4), 375-387.

Collins, C. K., Quirke, T., Overy, L., Flannery, K. & O'Riordan, R. (2016). The effect of the zoo setting on the behavioural diversity of captive gentoo penguins and the implications for their educational potential. *Journal of Zoo and Aquarium Research*, 4(2), 85-90.

Damasceno, J., Genaro, G., Quirke, T., McCarthy, S., McKeown, S. & O'Riordan, R. (2017). The effects of intrinsic enrichment on captive felids. *Zoo Biology,* 36(3), 186-192.

Davey, G., Henzi, P. & Higgins, L. (2005). The influence of environmental enrichment on Chinese visitor behavior. *Journal of Applied Animal Welfare Science*, 8(2), 131-140.

Davey, G. (2006a). Relationships between exhibit naturalism, animal visibility and visitor interest in a Chinese Zoo. *Applied Animal Behaviour Science*, 96(1), 93-102.

Davey, G. (2006b). Visitor behavior in zoos: A review. *Anthrozoös*, 19(2), 143-157.

Davey, G. (2007). Visitors' effects on the welfare of animals in the zoo: a review. *Journal of Applied Animal Welfare Science*, 10(2), 169–183.

Dierking, L. D., Adelman, L. M., Ogden, J., Lehnhardt, K., Miller, L. & Mellen, J. D. (2004). Using a behavior change model to document the impact of visits to Disney's

Animal Kingdom: A study investigating intended conservation action. *Curator: The Museum Journal*, 47(3), 322-343.

Dillon, J., Rickinson, M., Teamey, K., Morris, M., Young Choi, M., Sanders, D. & Benefield, P. (2006). The value of outdoor learning: evidence from research in the UK and elsewhere. *School Science Review*, 87 (320), 107-111.

Dutra, L. M. L. & Young, R. J. (2015). Can enrichment make Brazilian tapir spend more time on view to the public? *Journal of Applied Animal Welfare Science*, 18(1), 74-81.

Esson, M. (2009). Being in a hard place. BIAZA Research News 10, 1-3. Date last accessed March 30, 2013. On-line http://www.biaza.org.uk/uploads/Research/Research Newsletter/Vol 10. 2009.pdf.

Falk, J. H. (2001). Free-Choice Science Learning: Framing the Discussion. In J. H. Falk (Eds), *Free-Choice Science Education: How We Learn Science Outside of School.* Teacher's College Press, Columbia University: New York.

Falk, J. H. & Balling, J. D. (1982). The Field Trip Milieu: Learning and Behaviour as a Function of Contextual Events. *Journal of Educational Research*, 76(1), 22–28.

Falk, J. H. & Dierking, L. D. (1998). Free-choice learning: an alternative term to informal learning? *Informal Learning Environments Research Newsletter*, 2(1), 2.

Falk, J. H. & Dierking, L. D. (2000). Learning from Museums: visitor experiences and the making of meaning. Walnut Creek, CA. Alta Mira Press.

Falk, J. H., Reinhard, E. M., Vernon, C. L., Bronnenkant, K., Deans, N. L. & Heimlich, J. E. (2007). Why zoos & aquariums matter: Assessing the impact of a visit to a zoo or aquarium Silver Spring, MD: Association of Zoos & Aquariums.

Falk, J. H. & Storksdieck, M. (2010). Science Learning in a Leisure Setting. *Journal of Research in Science Teaching*, 47(2), 194–212.

Farrand, A., Hosey, G. & Buchanan-Smith, H. M. (2014). The visitor effect in petting zoo-housed animals: Aversive or enriching? *Applied Animal Behaviour Science*, 151, 117-127.

Fernandez, E. J., Tamborski, M. A., Pickens, S. R. & Timberlake, W. (2009). Animal-visitor interaction in the modern zoo: conflicts and interventions. *Applied Animal Behaviour Science*, 120(1), 1-8.

Finlay, T., James, L. R. & Maple, T. L. (1988). People's perceptions of animals the influence of zoo environment. *Environment and Behavior*, 20(4), 508-528.

Forde, S. A. (2006). The Influence of Zoo Visitors on the Behaviour and Welfare of Free-ranging Eastern Grey Kangaroos and Maras in Fota Wildlife Park. Unpublished MSc thesis. The University of Edinburgh.

Haigh, A., Butler, F., O'Riordan, R. & Palme, R. (2017). Managed parks as a refuge for the threatened red squirrel (*Sciurus vulgaris*) in light of human disturbance. *Biological Conservation*, 211, 29-36.

Ham, S. H. (2009). From interpretation to protection: Is there a theoretical basis? *Townsville, Queensland, Australia, April 13–17, 2010*, 98.

Ham, S. H. & Krumpe, E. E. (1996). Identifying Audiences and Messages for Nonformal Environmental Education-A Theoretical Framework for Interpreters. *Journal of Interpretation Research*, 1(1), 11-23.

Hayward, J. & Rothenberg, M. (2004). Measuring success in the 'Congo Gorilla Forest' conservation exhibition. *Curator: The Museum Journal*, 47(3), 261-282.

Hein, G. E. (1998). *Learning in the Museum*. Routledge.

Hinde, R. A. (1976). On describing relationships. *Journal of Child Psychology and Psychiatry*, 17(1), 1-19.

Hosey, G. R. (2000). Zoo animals and their human audiences: what is the visitor effect? *Animal Welfare*, 9(4), 343-357.

Hosey, G. R. (2005). How does the zoo environment affect the behaviour of captive primates? *Applied Animal Behaviour Science*, 90(2), 107-129.

Hosey, G. (2008). A preliminary model of human–animal relationships in the zoo. *Applied Animal Behaviour Science*, *109*(2), 105-127.

Hosey, G. (2013). Hediger revisited: how do zoo animals see us? *Journal of Applied Animal Welfare Science*, *16*(4), 338-359.

Hosey, G. & Melfi, V. (2015). Are we ignoring neutral and negative human–animal relationships in zoos? *Zoo Biology*, 34(1), 1-8.

Hungerford, H. R. & Volk, T. L. (1990). Changing learner behavior through environmental education. *The Journal of Environmental Education*, 21(3), 8-22.

Jensen, E. (2011). *Learning about Animals, Science and Conservation at the Zoo: Large-scale survey-based evaluation of the educational impact of the ZSL London Zoo Formal Learning programme.* A report to The Zoological Society of London.

Jensen, E. (2014). Evaluating children's conservation biology learning at the zoo. *Conservation Biology*, 28(4), 1004-1011.

Jensen, E. A., Moss, A. & Gusset, M. (2017). Quantifying long-term impact of zoo and aquarium visits on biodiversity-related learning outcomes. *Zoo Biology*, 36(4), 294-297.

Jones, H., McGregor, P. K., Farmer, H. L. A. & Baker, K. R. (2016). The influence of visitor interaction on the behavior of captive crowned lemurs (*Eulemur coronatus*) and implications for welfare. *Zoo Biology*, 35(3), 222-227.

Keane, C. W. (2005). The effects of zoo visitors on the behaviour of Western Lowland gorillas (*Gorilla gorilla gorilla*) Citron-Crested (*Cacatua sulphurea citrinocristata*) and Moluccan Cockatoos (*Cacatua moluccensis*). M.Sc. thesis, Trinity College, University of Dublin, Ireland.

Kola-Olusanya, A. (2005). Free-choice environmental education: understanding where children learn outside of school. *Environmental Education Research*, 11(3), 297–307.

Kuhar, C. W., Bettinger, T. L., Lenhardt, K., Tracy, O. & Cox, D. (2010). Evaluating for long-term impact of an Environmental Education Program at the Kalinzu Forest Reserve, Uganda. *American Journal of Primatology*, 72(5), 407-413.

Kratochvil, H. & Schwammer, H. (1997). Reducing acoustic disturbances by aquarium visitors. *Zoo Biology*, 16, 349-353.

Kyngdon, D. J., Minot, E. O. & Stafford, K. J. (2003). Behavioural responses of captive common dolphins (*Delphinus delphis*) to a ‘Swim-with-Dolphin’ programme. *Applied Animal Behaviour Science*, 81(2), 163-170.

Larsen, M. J., Sherwen, S. L., & Rault, J. L. (2014). Number of nearby visitors and noise level affect vigilance in captive koalas. *Applied Animal Behaviour Science*, 154, 76-82.

Lindemann-Matthies, P. & Kamer, T. (2006). The influence of an interactive educational approach on visitors' learning in a Swiss zoo. *Science Education*, 90(2), 296-315.

Luebke, J. F. & Matiasek, J. (2013). An exploratory study of zoo visitors' exhibit experiences and reactions. *Zoo Biology*, 32(4), 407-416.

Luebke, J. F., Watters, J. V., Packer, J., Miller, L. J. & Powell, D. M. (2016). Zoo Visitors' Affective Responses to Observing Animal Behaviors. *Visitor Studies*, 19(1), 60-76.

Lukas, K. E. & Ross, S. R. (2005). Zoo Visitor Knowledge and Attitudes toward Gorillas and Chimpanzees. *The Journal of Environmental Education*, 36(4), 33.

Mallapur, A. & Chellam, R. (2002). Environmental influences on stereotypy and the activity budget of Indian leopards (*Panthera pardus*) in four zoos in southern India. *Zoo Biology*, 21(6), 585-595.

Margulis, S. W., Hoyos, C. & Anderson, M. (2003). Effect of felid activity on zoo visitor interest. *Zoo Biology*, *22*(6), 587-599.

Marino, L., Lilienfeld, S. O., Malamund, R., Nobis, N. & Broglio, R. (2010). Do zoos and aquariums promote attitude change in visitors? A critical evaluation of the American zoo and aquarium study. *Society & Animals*, 18, 126-138.

Mellen, J. & MacPhee, M. S. (2001). Philosophy of environmental enrichment: past, present, and future. *Zoo Biology*, 20(3), 211-226.

Milan, L. M. & Wourms, M. K. (1992). A zoological park is not just another museum. *Curator: The Museum Journal*, 35(2), 120-136.

Morgan, K. N. & Tromborg, C. T. (2007). Sources of stress in captivity. *Applied Animal Behaviour Science*, 102(3), 262-302.

Moscardo, G., Woods, B. & Saltzer, R. (2004). The role of interpretation in wildlife tourism. Common Ground Publishing, 231-251.

Moss, A. & Esson, M. (2010). Visitor interest in zoo animals and the implications for collection planning and zoo education programmes. *Zoo Biology*, 29(6), 715-731.

Moss, A., Esson, M. & Francis, D. (2010). Evaluation of a third-generation zoo exhibit in relation to visitor behavior and interpretation use. *Journal of Interpretation Research*, 15, *11–28.*

Moss, A. & Esson, M. (2013). The Educational Claims of Zoos: Where Do We Go from Here? *Zoo Biology*, 32(1), 13-18.

Moss, A., Jensen, E. & Gusset, M. (2015). Evaluating the contribution of zoos and aquariums to Aichi Biodiversity Target 1. *Conservation Biology*, 29(2), 537-544.

Mun, J. S. C., Kabilan, B., Alagappasamy, S. & Guha, B. (2013). Benefits of Naturalistic Free-Ranging Primate Displays and Implications for Increased Human–Primate Interactions. *Anthrozoös*, 26(1), 13-26.

Myers Jr, O. E. & Saunders, C. D. (2002). Animals as links toward developing caring relationships with the natural world. *Children and nature: Psychological, sociocultural, and evolutionary investigations*, 153-178.

Myers, O. E., Saunders, C. D. & Birjulin, A. A. (2004). Emotional dimensions of watching zoo animals: An experience sampling study building on insights from psychology. *Curator: The Museum Journal*, 47(3), 299-321.

Nimon, A. J. & Dalziel, F. R. (1992). Cross-species interaction and communication: a study method applied to captive siamang (*Hylobates syndactylus*) and long-billed corella (*Cacatua tenuirostris*) contacts with humans. *Applied Animal Behaviour Science*, 33(2), 261-272.

O'Donovan, D., Hindle, J. E., McKeown, S. & O'Donovan, S. (1993). Effect of visitors on the behaviour of female cheetahs (*Acinonyx jubatus)* and cubs. *International Zoo Yearbook*, 32(1), 238-244.

Ogden, J. & Heimlich, J. E. (2009). Why focus on zoo and aquarium education? *Zoo Biology*, 28(5), 357–60.

Orams, M. B. & Hill, G. J. (1998). Controlling the ecotourist in a wild dolphin feeding program: is education the answer? *The Journal of Environmental Education*, 29(3), 33-38.

Osborne, J., Simon, S. & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. *International Journal of Science Education*, 25(9), 1049–1079.

Ozella, L., Favaro, L., Carnovale, I. & Pessani, D. (2015a). Pond use by captive African penguins (*Spheniscus demersus*) in an immersive exhibit adjacent to human bathers. *Journal of Applied Animal Welfare Science*, 18(3), 303-309.

Ozella, L., Anfossi, L., Di Nardo, F. & Pessani, D. (2015b). Effect of weather conditions and presence of visitors on adrenocortical activity in captive African penguins (*Spheniscus demersus*). *General and comparative endocrinology*, 242, 49-58.

Packer, J. (2006). Learning for Fun: The Unique Contribution of Educational Leisure Experiences. *Curator: The Museum Journal*, 49(3), 329–344.

Palmberg, I. E. & Kuru, J. (2000). Outdoor Activities as a Basis for Environmental Responsibility. *The Journal of Environmental Education*, 31(4), 22–36.

Patrick, P. G., Matthews, C. E., Ayers, D. F. & Tunnicliffe, S. D. (2007). Conservation and Education: Prominent Themes in Zoo Mission Statements. *The Journal of Environmental Education*, 38(3), 53–59.

Phipps, M. (2010). Research trends and findings from a decade (1997–2007) of research on informal science education and free-choice science learning. *Visitor Studies*, 13(1), 3-22.

Piaget, J. (1951). *The child's conception of the world* (No. 213). (A. Tomlinson & J. Tomlinson, Trans.) Lanham, Maryland: Rowman & Littlefield.

Quadros, S., Goulart, V. D., Passos, L., Vecci, M. A. & Young, R. J. (2014). Zoo visitor effect on mammal behaviour: Does noise matter? *Applied Animal Behaviour Science*, 156, 78-84.

Quirke, T. (2011) ‘Cheetah Behaviour in Captivity: A study on Behaviour and the Effects of Environmental Enrichment’ PhD Thesis. University College Cork, Ireland.

Rabb, G. B. & Saunders, C. D. (2005). The future of zoos and aquariums: conservation and caring. *International Zoo Yearbook*, 39(1), 1-26.

Ramsay, N. F. (1995). The influence of environmental constraints on aspects of the eco-ethology of the lemurs (*Lemur catta*) Linnaeus 1785 and (*Eulemur fulvus mayottensis*) Schlegel 1866 in wild and captive environments. PhD Dissertation, University College Cork, Ireland.

Randler, C., Baumgärtner, S., Eisele, H. & Kienzle, W. (2007). Learning at workstations in the zoo: A controlled evaluation of cognitive and affective outcomes. *Visitor Studies*, 10(2), 205-216.

Reade, L. S. & Waran N. K. (1996). The modern zoo: how do people perceive zoo animals? *Applied Animal Behaviour Science,* 47(1), 109-118.

Roschelle, J. (1995) "Learning in Interactive Environments: Prior Knowledge and New Experience," in Falk, J. H. & Dierking, L. D. (Eds.) *Public Institutions for Personal Learning: Establishing a Research Agenda,* Washington, DC: American Association of Museums, 37–52.

Sherwen, S. L., Magrath, M. J., Butler, K. L., Phillips, C. J. & Hemsworth, P. H. (2014). A multi-enclosure study investigating the behavioural response of meerkats to zoo visitors. *Applied Animal Behaviour Science*, 156, 70-77.

Sherwood, K. P., Rallis, S. F. & Stone, J. (1989). Effects of live animals vs. preserved specimens on student learning. *Zoo Biology*, 8(1), 99-104.

Shettel-Neuber, J. (1988). Second and Third-Generation Zoo Exhibits A Comparison of Visitor, Staff, and Animal Responses. *Environment and Behavior*, 20(4), 452-473.

Skibins, J. C. & Powell, R. B. (2013). Conservation caring: Measuring the influence of zoo visitors' connection to wildlife on pro-conservation behaviors. *Zoo Biology*, 32(5), 528-540.

Skibins, J. C., Powell, R. B. & Hallo, J. C. (2013). Charisma and conservation: charismatic megafauna's influence on safari and zoo tourists' pro-conservation behaviors. *Biodiversity and Conservation*, 22(4), 959-982.

Smith, L., Broad, S. & Weiler, B. (2008). A closer examination of the impact of zoo visits on visitor behaviour. *Journal of Sustainable Tourism*, 16(5), 544-562.

Smith, L. (2009). Identifying behaviors to target during zoo visits. *Curator: The Museum Journal*, 52(1), 101-115.

Sommer, R. 1972. What do we learn at the zoo? *Natural History*, 81, 26-27. 84-85.

Stern, M. J. & Powell, R. B. (2013). What leads to better visitor outcomes in live interpretation? *Journal of Interpretation Research*, 18(2), 9-43.

Stevens, J., Thyssen, A., Laevens, H. & Vervaecke, H. (2013). The influence of zoo visitor numbers on the behaviour of harbour seals (*Phoca vitulina*). *Journal of Zoo and Aquarium Research*, 1(1), 31-34.

Storksdieck, M., Ellenbogen, K. & Heimlich, J. E. (2005). Changing minds? Reassessing outcomes in free-choice environmental education. *Environmental Education Research*, 11(3), 353-369.

Swaisgood, R. R. & Shepherdson, D. J. (2005). Scientific approaches to enrichment and stereotypies in zoo animals: what's been done and where should we go next? *Zoo Biology*, 24(6), 499-518.

Swaisgood, R. & Shepherdson, D. (2006). Environmental enrichment as a strategy for mitigating stereotypies in zoo animals: a literature review and meta-analysis. In G. Mason & J. Rushen (Eds.) *Stereotypic Animal Behaviour: Fundamentals and Applications to Welfare*, CAB Publishing, 256-285.

Swanagan, J. S. (2000). Factors influencing zoo visitors' conservation attitudes and behaviour. *Journal of Environmental Education*, 31(4), 26-31.

Szokalski, M. S., Foster, W. K. & Litchfield, C. A. (2013). Behavioral monitoring of big cats involved in 'behind-the-scenes' zoo visitor tours. *International Journal of Comparative Psychology*, *26*(1), 83-104.

Tarou, L. R. & Bashaw, M. J. (2007). Maximizing the effectiveness of environmental enrichment: suggestions from the experimental analysis of behaviour. *Applied Animal Behaviour Science*, 102(3), 189-204.

Tilden, F. (1957). *Interpreting our heritage: Principles and practices for visitor services in parks, museums, and historic places*. University of North Carolina Press.

Tofield, S., Coll, R. K., Vyle, B. & Bolstad, R. (2003). Zoos as a source of free choice learning. *Research in Science & Technological Education*, 21(1), 67-99.

Tunnicliffe, S. D., Lucas, A. M. & Osborne, J. (1997). School visits to zoos and museums: a missed educational opportunity? *International Journal of Science Education*, *19*(9), 1039–1056.

Tunnicliffe, S.D. (2004). 'Learning in Zoos and Farms' In M. Braund & M. Reiss (Eds.), *Learning Science outside the classroom*. London: Routledge Falmer, 95-112.

UNESCO. 1978. Final report: *Intergovernmental Conference on Environmental Education*, Organized by UNESCO in Cooperation with UNEP, Tbilisi, USSR, October 14–26, 1977, Paris: UNESCO ED/MD/49.

Visscher, N. C., Snider, R. & Vander Stoep, G. (2009). Comparative analysis of knowledge gain between interpretive and fact-only presentations at an animal training session: an exploratory study. *Zoo Biology*, 28(5), 488-495.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press. 79-91.

Wagner, K., Chessler, M., York, P. & Raynor, J. (2009). Development and implementation of an evaluation strategy for measuring conservation outcomes. *Zoo Biology*, *28*(5), 473-487.

Wagoner, B. & Jensen, E. (2010). Science learning at the zoo: Evaluating children's developing understanding of animals and their habitats. *Psychology & Society*, 3(1), 65-76.

Whitehouse, J., Waller, B. M., Chanvin, M., Wallace, E. K., Schel, A. M., Peirce, K., Mitchell, H., Macri, A. & Slocombe, K. (2014). Evaluation of public engagement activities to promote science in a zoo environment. *PloS one*, *9*(11), p. e113395.

Wood, W. (1998) Interactions among environmental enrichment, viewing crowds, and zoo chimpanzees (*Pan troglodytes*). *Zoo Biology*,17, 211-230.

Woolway, E. E. & Goodenough, A. E. (2017). Effects of visitor numbers on captive European red squirrels (*Sciurus vulgaris*) and impacts on visitor experience. *Zoo Biology*, 36(2), 112-119.

Young, R. J. (2003). *Environmental Enrichment for Captive Animals*. Blackwell.

Section A

Animal behaviour

Chapter 3

The effects of environmental and visitor variables on the behaviour of free-ranging ring-tailed lemurs (*Lemur catta*) in captivity.

A modified version of this chapter has been published in Zoo Biology in the following form; Collins, C., Corkery, I., Haigh, A., McKeown, S., Quirke, T., O'Riordan, R. 2017. The effects of environmental and visitor variables on the behavior of free-ranging ring-tailed lemurs (Lemur catta) in captivity. Zoo Biology, Vol. 36, Issue 4, p. 250-260. See Appendix 6.

Abstract

The effect of the zoo environment on captive animals is an increasingly studied area of zoo research, with visitor effects and exhibit design recognised as two of the factors that can contribute to animal welfare in captivity. It is known that in some situations visitors may be stressful to zoo-housed primates, and this may be compounded by environmental factors such as the weather, the time of day and zoo husbandry routines. Exhibit design and proximity of the public are also known to influence behavioural responses of primates to visitors; however, there is minimal research on free-ranging zoo animals, even though they are potentially subjected to intense interactions with visitors. The current study explores the effect of the zoo environment, several visitor variables and specific animal-visitor interactions on the behaviour of free-ranging ring-tailed lemurs (*Lemur catta*) at Fota Wildlife Park, Ireland. Data were obtained through scan samples collected over 18 months (n = 12,263) and analysed using a range of statistical tests, including general estimating equations (GEE). Results demonstrate that the behaviour of the free-ranging lemurs at Fota Wildlife Park is affected by season, weather and time of day. Similarities in feeding behaviour exist between the free-ranging group and lemurs in the wild when resources are plentiful. Visitor variables had a limited effect on lemur behaviour and behavioural diversity level. Lemurs rarely reacted to visitors when specific interactions were considered. Generally, the results indicate that the ring-tailed lemurs in this study have adapted well to the zoo environment and habituated to visitors. Future work should focus on free-range lemurs in other zoos with varying husbandry routines and visitor restrictions in place, and the effect of the free-range environment on other species.

3.1 Introduction

As fragmentation and destruction of natural habitats continues, the potential for zoos to contribute to conservation and education has increased (Rabb, 2004). Most zoos list conservation and education as two of their main goals (Patrick et al., 2007), although many visitors report that entertainment is their primary reason for visiting a zoo (Reade and Waran, 1996). However, visitors may be more likely to engage in pro-conservation behaviour, if they develop a positive connection to wildlife during a zoo visit (Skibins and Powell, 2013). Yet, there is limited quantifiable data surrounding animal-visitor interactions, even though they are a daily part of life in the zoo. Thus, the stated goals of zoos might be incompatible, if the visitors to be educated and entertained are causing stress and diminished welfare to captive animals as a result of their presence and/or behaviour (Hosey, 2005; Fernandez et al., 2009).

Human-animal relationships (HARs) can develop in the zoo over time from interactions between animals and familiar humans, such as keepers (Hosey, 2008; Hosey et al., 2018). The relationship between keeper and animal could extend as far as a human-animal bond (HAB), which signifies a strong reciprocal attachment (Hosey et al., 2018). Though it is unlikely that HABs could form between zoo-housed animals and visitors, since one of the criteria of the HAB is that the relationship must be persistent and include recognition (Russow, 2002; Hosey et al., 2018). Even HARs are unlikely to form with individual visitors, rather an animal probably perceives all unfamiliar humans in a general way and one HAR forms with all visitors (Hosey, 2008). Of course, zoo visitors may perceive this differently; some visitors report a positive emotional connection to a specific animal or species while viewing them (Myers et al., 2004; Clayton et al., 2009). The animal’s perception of the interaction will vary depending on variables such as personality and previous experience with humans. Cumulative positive experiences with familiar humans could lead to more positive perceptions of unfamiliar humans like visitors (Hosey, 2008). This has led to the development of a model which can help to predict an animal’s response to visitors (which varies from visitors inducing high stress to visitors being enriching) based largely on that animal’s previous experience with both familiar and unfamiliar humans (Hosey, 2008; Claxton, 2011). However, empirical evaluations of direct human-animal interactions (HAI) in the zoo are rare compared to other areas like agricultural settings (Hosey and Melfi, 2014), even though visitor experiences involving close contact with animals are becoming more prevalent in zoos. In fact, in the UK, 16 out of 36 BIAZA (British and Irish Association of Zoos and Aquariums) zoos currently offer visitor feeding experiences with lemurs (Jones et al., 2016). One study which observed the behavioural response of crowned lemurs (*Eulemur coronatus*) during a visitor feeding experience found that the experience had very little effect on the behaviour of the primates (Jones et al., 2016). The authors conclude that there were even indications of improved welfare through reduced lemur aggression (compared to keeper only feeds), perhaps due to reduced competition, and no indication of compromised welfare.

Visitor effects, a more established area of zoo research, considers the effect of visitors on the behaviour (and more recently physiological effects, Clark et al., 2012) of exhibited animals. As with HAR and HAI, the presence of visitors has been described as potentially having no effect, an enriching effect, or a stressful effect on captive animals (Hosey, 2000). Research in this area has primarily focused on primates, and broadly, it has shown that as visitor numbers increase, visitor-directed aggression, con-specific aggression, threats and activity levels increase, while feeding, resting and affiliative behaviours decrease (Glatston et al., 1984; Mitchell et al. 1991; Wood, 1998; Birke, 2002; Wells, 2005; Carder and Semple, 2008; Kuhar, 2008). Large, active, noisy crowds may be the most stressful to captive primates (Mitchell et al., 1992; Hosey, 2000, 2005). Specifically, in ring-tailed lemurs (*Lemur catta*) housed in traditional zoo enclosures, visitor presence has been associated with increased activity and aggression, but decreased grooming; this display of behaviour expressed by lemurs and monkeys when zoo visitors are present has been described as stressful excitement (Chamove et al., 1988; Hosey, 2008). However, this is a broad summary, and it is not only species type and individual animal characteristics, but several environmental variables of the zoo setting such as season, weather, time of day, husbandry routines and exhibit design that may influence behavioural responses to visitors (Hosey, 2000; Clark et al., 2012; Stoinski et al., 2012).

A recurring finding from visitor effect studies, which extends to various taxonomic groups, is that the ability to retreat from visitors lessens visitor-induced stress (Carlstead and Shepherdson, 2000; Hosey, 2000; Collins and Marples, 2015). Thus, exhibit design is of significant importance when considering visitor effects (Sherwen et al., 2015). One area that visitor effect studies have almost entirely overlooked is that of free-ranging zoo animals. Free-ranging zoo animals have the opportunity to retreat from visitors but can potentially be exposed to more intense interactions with the public, who might attempt to chase, touch or even feed free-ranging animals (Jens et al., 2012; Mun et al., 2013), depending on the zoo management strategy. There is evidence that visitors prefer to see animals in more naturalistic settings and specifically free-ranging animals, and that visitors may develop more positive attitudes to free-ranging animals (Finlay et al., 1988; Coe, 1989; Price et al., 1994; Hosey, 2005; Mun et al., 2013), but there is only minimal research on how free-ranging animals are affected by their environment and zoo visitors.

A recent study on two kangaroo species (*Macropus fuliginosus fuliginosus*, and *Macropus rufus*), who were kept in a free-range exhibit, found that the animals' behaviour changed little between quiet and busy days (Sherwen et al., 2015). The absence of avoidance behaviour, aggression or change in FGM (faecal glucocorticoid metabolites) concentration between quiet and busy days suggested that visitors had a minimal effect on the kangaroos, however the kangaroos did spend most of their time in retreat zones when visitors were present (Sherwen et al., 2015). Additionally, Choo et al. (2011) investigated several aspects of visitors on the behaviour of free-ranging captive orang-utans (*Pongo pygmaeus*) and found that visitors had little influence on the primates' behaviour and that the orang-utans in their study have primarily habituated to visitors, although visitor proximity to orang-utans was associated with a reduction in play behaviour. However, in both studies visitor access was in some way restricted, so that they were not able to touch, feed or approach too closely during the study period which inherently limits the potential for HAIs.

Mun et al. (2013) considered both primate and visitor reaction at three different free-range exhibits at Singapore Zoo. The exhibits included cotton-top tamarins (*Saguinus oedipus*), where some barriers and ranging restrictions were in place, White-faced saki (*Pithecia pithecia*), where no barriers or ranging restrictions were in place, and Orangutan (*Pongo pygmaeus* and *Pongo abelii*), where hotwire barriers and ranging restrictions were in place. Visitors most enjoyed seeing the cotton-top tamarins, which is the exhibit where animals were the most visible (92.1%) and in closest proximity to visitors. However, this is also the exhibit that attracted the highest number of visitors and where the most intense negative animal-visitor interactions occurred, including touching or feeding by humans and biting or scratching by the tamarins (Mun et al., 2013). However, visitors thought that all three exhibits contributed to enhanced animal welfare, and that they had high educational value.

Additionally, Price et al. (1994) discovered that visitors spent more time looking at free-ranging cotton-top tamarins (*Saguinus oedipus*), made more comments about them, perceived them to have improved welfare and a higher educational value than their caged counterparts. Apenheul Primate Park, Netherlands and Durrell Wildlife Park, UK use several different ways of communicating to the public about free-ranging animals, including 'guard keepers' and volunteers; however, undesirable animal-visitor interactions still occur (Jens et al., 2012; Price et al., 2012). Yet, more than 90% of visitors reported that they appreciate the close encounters with the animals (Jens et al., 2012). Price et al. (2012) found the monkeys' reaction to visitors varied between the two zoos and amongst the species studied, which suggests differences in species temperament and adaptation to their surroundings were important in the free-ranging animals observed in the study.

An early study considered how environmental variables affect ring-tailed lemur behaviour in a range of captive environments (Ramsay, 1995). It was found that lemur behaviour varied based on time of day and season in particular. This pattern was most evident in the free-ranging group at Fota Wildlife Park, which may be attributable to the lemurs' ability to feed naturally (Ramsay, 1995). Although Ramsay (1995) speculated that disturbance from visitors may influence the lemurs' use of the park during the summer months, the behaviour of the free-range group was found to be most similar to wild lemurs.

When considering the effect of the zoo environment on a captive species, it is practical to first consider the natural history of the species and the behaviour of conspecifics in the wild (Hosey et al. 2013; Sherwen et al., 2015). Ring-tailed lemurs are characterised by their behavioural flexibility and adaptability (Gould et al., 1999; Sauther et al., 1999). Yet, the wild population continues to decrease due to habitat destruction and hunting and they are now classified as endangered (IUCN, 2014). One study refers to a recent rapid decline in the wild lemur population and describes lemurs as 'the most threatened group of mammals on Earth' (LaFleur et al., 2016, p. 320), though according to Murphy et al. (2017) the authors may have overestimated the severity of the population decline. Lemurs are a commonly held species in captivity with an estimated 4,000 ring-tailed lemurs in zoos around the world as of 2018 (Species 360, 2018). While the future may comprise life in zoos and wildlife parks for this species, their adaptability, social intelligence, opportunistic behaviour and ability to adjust to new environments make them one of the most suitable primate species for free-range displays (Jolly, 1966a; Keith-Lucas et al., 1999; Dishman et al., 2009). However, more research is needed to clarify the animals' behavioural response to the zoo setting, in order for zoos to meet their goals of visitor enjoyment, education, conservation and animal welfare.

The purpose of the present research was to examine:

1) The effects of environmental and visitor variables of the zoo on the behaviour of free-ranging ring-tailed lemurs.

2) The relationship between crowd size and visitor frequency on the behavioural diversity level of the lemur group.

3) Interactions between zoo visitors and free-ranging ring-tailed lemurs.

3.2 Methodology

Study site

The study took place at Fota Wildlife Park (Fota), Carrigtwohill, Ireland (51.889585º N, 8.311276º W). Fota Wildlife Park has kept free-ranging ring-tailed lemurs since 1983. The animals are able to roam the entire park; their movements are completely unrestricted even at night. Staff have even observed the lemurs leaving the park, though they are most often located in the lower half of the park, where all of the data for this study were recorded. Visitors are able to directly approach the lemurs, and they are not expected to follow a particular path to view the lemurs. A large sign at the entrance to the park outlines the rules that visitors are expected to obey, including not to touch, feed or chase the animals (Figure 3.1B). In 2006, with the aim of promoting both lemur welfare and visitor enjoyment, Fota Wildlife Park began its 'lemur patrol' project. 'Lemur patrol' are staff employed by the park to manage and protect the free-ranging lemur group. The data used in the current study examines two eight-month periods of that project between March 2009 and October 2010. At the time that the research occurred, the wildlife park was approximately 75 acres in size and received about 300,000 visitors annually.

Animals

The study involved a group of free-ranging ring-tailed lemurs. All of the animals in the study were captive born and mother-reared. The number of animals varied between 13 lemurs (five males; eight females) in 2009 and 11 lemurs (four males; seven females) in 2010, after one male lemur died and one female lemur was transferred. Ideally, lemur patrol staff attempt to keep the visitors approximately one meter away from the lemurs; however, this is not always possible and close contact interactions, such as touching, do occur. The study site consisted of a woodland environment with 26 different species of predominantly native trees, a lake, a stream and grassland areas. The lemurs had a 'base' (see Figure 3.1A), which included a sheltered hut where they were fed a scatter feed of monkey pellets, vegetables and a small amount of fruit by staff twice per day; natural foraging also contributed to their diet. The free-ranging ring-tailed lemurs at Fota Wildlife Park are known to feed on 20 species of plant, with considerable seasonal variation (Ramsay, 1995). Common Yew (*Taxus baccata*) is the most frequently foraged item (Foley, 2016).

A. **B.**

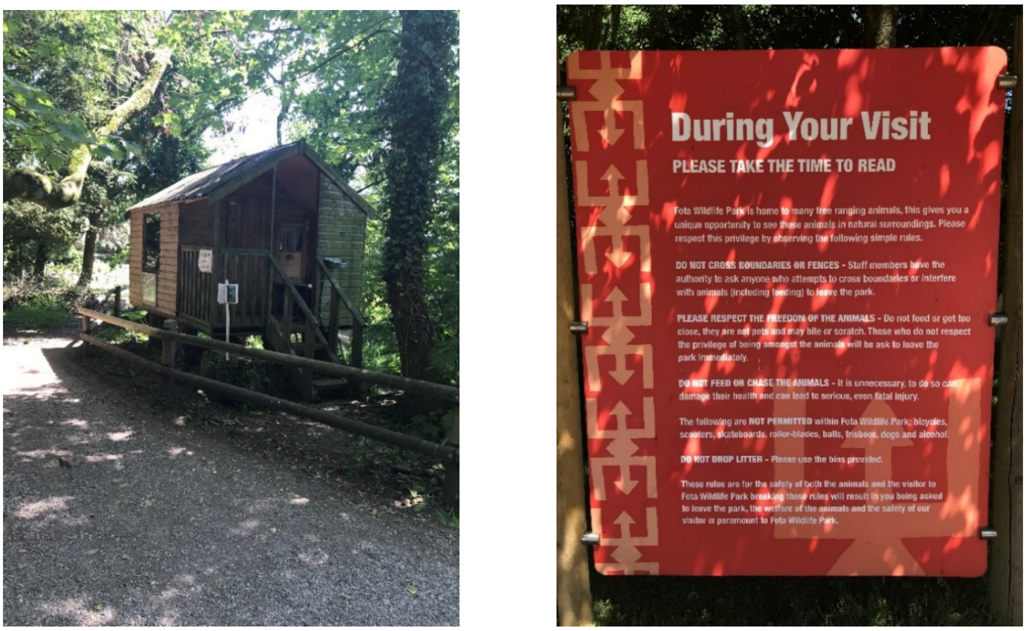


Figure 3.1. A) Lemur 'base' at Fota Wildlife Park and B) the rules that visitors are expected to follow at the park.

Procedure

Data were recorded using instantaneous scan sampling with an inter-scan interval of 10 minutes between approximately 09:30 h and 17:30 h each day (Altmann, 1974). The following were recorded during each scan, which began when the first lemur’s behaviour was recorded and ended when the last lemur’s behaviour was recorded: the number of visitors present, the behaviour, position and location of the lemur group, any outside stimulus, the presence of a baby stroller, since primate interest in strollers is a concern with free-ranging monkeys (Jens et al., 2012), the weather conditions and the time (see Table 3.1, 3.2 and 3.3 for details of variables and recording methods). During the scan, lemur-visitor interactions were also recorded. This included any overt visitor behaviour towards any lemur and any attempt of lemurs to interact with visitors. Any subsequent reaction of either the lemurs or visitors to the interaction was also recorded if it occurred during the duration of the scan. Lemur-visitor interactions that occurred outside the scan were excluded from the study. This led to a total of 12,263 instantaneous scans samples on 300 days during the study period.

Several different researchers, who were trained by the primary researcher and followed a standardised protocol, recorded data each year. It was not possible to test inter-observer reliability, therefore, ‘observer’ was initially treated as an independent variable; however, preliminary results showed virtually no observer effect so ‘observer’ was discounted from any further analysis. Lemurs had habituated to the presence of the researchers and did not impact the primates’ behaviour. Researchers were not counted as visitors, and they followed the lemur group throughout the park during the day; they did not interfere with the lemurs or visitors, but they came close enough to observe the interactions and behaviours of the lemurs and the visitors. The lemurs were difficult to distinguish individually; and, because of the large number of variables that were recorded during each scan, behaviour of the group was observed, by recording the number of individuals engaged in a specific behaviour at each scan sample point. Since lemurs are known to synchronise their activities this was considered an effective method of data collection (Sauther et al., 1999).

Table 3.1. Ethogram of common lemur behaviours and positions at Fota Wildlife Park.

Behaviors	Definition
Not visible	Out of sight (excluding hut)
Inactive	Lying down, sitting, no movement, sleeping, no contact or interaction with conspecifics
Groom	Autogroom; biting, licking, scratching
Feed/Forage	Ingesting food; eating, drinking, looking for food; head in contact with the ground, uncovering or searching for a food item.
Locomotion	Any movement from one location to another; walking, running, climbing
Affiliative	Allo-grooming; huddled or basking together; play
Hut	Not visible, but known to be in the hut
Positions	
‘Up’	Elevated on any structure such as a roof, table, tree
‘Down’	Touching the ground

Data analysis

Before applying any statistical models, data exploration, following the protocol described in Zuur et al. (2010) was carried out. Only observations including the entire lemur group were included in the analysis (n = 11,997). The total number of times specific lemur behaviours and positions were observed during varying environmental and visitor variables were modeled using generalised estimation equations (GEE) with a Poisson distribution and a normal error structure. Covariates considered in the model include: time, season, weather, stimulus, location, visitor number, visitor behaviour and presence of a baby stroller (Table 3.2 and 3.4); all dependent variables were modeled separately. All interactions investigated in the model are shown in Table 3.4. The package geeM (McDaniel and Henderson, 2013) in the software R version 3.2.3 was used to estimate the parameters of the GEEs. Generalised estimating equations are an extension of generalised linear models and allow for correlated responses (Diggle et al., 1995). Originally, these methods were developed for longitudinal data and repeated measures models. An auto-regressive correlation was specified; the correlation between observations separated by one-time unit (each consecutive sampling day) is likely to be more similar than those separated by larger time units.

Additionally, as there is substantial evidence that increased behavioural diversity is a positive result of a treatment or condition (Carlstead and Shepherdson, 2000; Clark and Melfi, 2012), overall behavioural diversity (BD) level was considered as an indicator of welfare. Behavioural diversity was calculated for each observation, using the Shannon-Weaver diversity index H (Shannon & Weaver, 1949). The formula for the Shannon-Weaver index is:

$$H = - \sum (pi \ln pi)$$

Where *pi* is the proportion of time engaged in the *i*th behaviour. A higher value of H represents greater behavioural diversity, either a greater number of behaviours and/or a more even performance of different behaviours observed. For a full description of the methodology see Collins et al. (2016). Spearman's rank correlation tests (SPSS 22, Inc., USA) were used to examine the relationship between behavioural diversity and visitor number. Both the instantaneous and daily effect of visitors were analysed (Kuhar, 2008; Stevens et al., 2013). To test the instantaneous effect of visitors (e.g. 'crowd size', Fernandez et al., 2009, p. 5) the full dataset (n = 11,997) was used and for each scan it was noted how many visitors were present (visitor number as a continuous independent variable; corresponding behavioural diversity level as the continuous dependent variable). To test the daily or cumulative effect of visitors (e.g. 'visitor frequency', Fernandez et al., 2009, p. 5) on behavioural diversity, the total number of visitors per day was calculated by summing the total number of visitors recorded per scan sample for one day, while this does not include visitors that viewed lemurs between scans it was as accurate as was feasible for this study, and then the mean behavioural diversity was calculated per day (n = 300).

Table 3.2. Summary of environmental and visitor variables included in the study.

A. Environmental variables	**Definition of categories**	**Recording Method**
Time	1 = Morning (9:30 – 12:59) 2 = Afternoon (13:00-17:30)	Each scan was categorised as either morning or afternoon.
Season	1 = March/April 2 = May/June 3 = July/August 4 = September/October	Data were collected between March – October and categorized accordingly.
Weather	1 = Very bad; constant rain, wind, cold 2 = Poor; some rain and wind, cool 3 = Okay; some cloud, light wind 4 = Very good; sunny, mild, no wind	Data were recorded at every scan by the observer on a scale of 1-4.
Stimulus	1 = No 2 = Yes	The presence of a stimulus (zoo vehicle, zoo staff, other species present) was recorded at each scan.
Location	Locations 1 – 5 (see Figure 1)	The location of the group was recorded at each scan.
B. Visitor related variables	**Definition of categories**	**Recording Method**
Visitor number	Total number of visitors present when a scan occurred	Visitors had to be within 3m of any lemur with at least one member of the visitor group actively watching/looking at/engaged with the lemurs, rather than walking by; visitors were counted and recorded by the observer.
Visitor behaviour	1 = Visitors compliant with park rules or not present 2 = Visitors not compliant with park rules (See Table 3.3 for details of specific behaviours)	If any member of the visitor group engaged or attempted to engage in any behaviour not compliant with park rules, the incident was recorded for that scan; unsuccessful actions that may have been stopped by staff were included here.
Baby Stroller	1 = No baby stroller is present 2 = Baby stroller is present	The presence or absence of at least one child's stroller was recorded at each scan.

Finally, to investigate the number of scans during which an interaction occurred between zoo visitors and free-ranging ring-tailed lemurs some brief descriptive statistics are offered. Then, to explore if specific visitor behaviours were associated with specific lemur actions, a Fisher's Exact Test was performed. Hosey et al. (2013; p. 475) defines interaction as 'some kind of behaviour performed by one individual that influences the behaviour of another [individual]', based on the definition by Estep and Hetts (1992). Additionally, it was considered that visitor behaviour may not lead to an obvious lemur response; however, only observations that included an overt visitor behaviour toward the lemurs (n=76) were included (Table 3.3).

Table 3.3. Lemur-visitor interactions observed during the study.

A. Lemur Behaviour	**Description of Behaviour**	**Recording Method**
1 = No response	1 = no action directed at visitor group by lemurs	If any lemurs engaged in any of these behaviours (2, 3 or 4) during the scan the behaviour was recorded for that scan. Not all actions were successful (e.g. obtaining food), but an overt attempt (within 1m) that may have been interrupted or stopped by staff was included here.
2 = Approach	2 = lemur(s) approach visitors	
3 = Food related	3 = lemur(s) beg, receive or attempt to get food	
4 =Retreat	4 = lemur(s) run away	
B. Visitor Behaviour	**Description of Behaviour**	**Recording Method**
1 = Approach	1 = visitor(s) pet or touch lemurs	If any member of the visitor group engaged in any of these behaviours during the scan the behaviour was recorded for that scan; not all actions were successful, but an overt attempt (within 1m) that may have been stopped by staff was included here.
2 = Food related	2 = visitor(s) give food to lemurs	
3 = Negative action (Frighten)	3 = visitor(s) chase, kick throw something at lemurs	

Post hoc testing using adjusted residuals to calculate p-values was performed to determine where differences amongst cells of the contingency table occurred (see Beasley and Schumacker, 1995). Where multiple comparisons occurred, all p-values were adjusted using the Bonferroni correction. Throughout the analysis all tests were two-tailed and the accepted alpha level was $p<0.05$ unless stated otherwise.

3.3 Results

3.3.1 Effect of environmental variables on lemur behaviour and position

In summary, the effect of the environmental variables within the zoo setting had varying effects on ring-tailed lemur behaviour and positions. Season and weather influenced all lemur behaviours (except feeding); they had similar effects on grooming and hut behaviour with an increase in grooming later in the season and as the weather improved, and a converse decrease in hut use across both variables. Increased affiliative behaviour and inactivity were observed more often later in the season. Additionally, lemurs spent less time 'not visible,' and in the hut and more time in locomotion and on the ground as weather conditions improved. From morning to afternoon (time), there was a decrease in feeding/foraging and an increase in inactivity and hut use. The presence of a zoo stimulus was associated with an increase in feeding/foraging, locomotion and time on the ground, and a decrease in affiliative behaviour. Time and stimulus interact in their effects on several behaviours; for example, time of day had no effect on the number of lemurs on the ground when there is a stimulus present, but in the absence of a stimulus, more lemurs are recorded on the ground in the afternoon (Figure 3.2 and Table 3.4).

3.3.2 Effect of visitor variables on lemur behaviour and position

Visitor related variables had varying effects on lemur behaviour. As the number of visitors present at any one time increased, the numbers of lemurs in locomotion and on the ground also increased. Visitor behaviour did not affect any lemur behaviour or position. The presence of a baby stroller was associated with a decrease in locomotion and grooming; however, if the stroller was present in the afternoon grooming increased (Table 3.4).

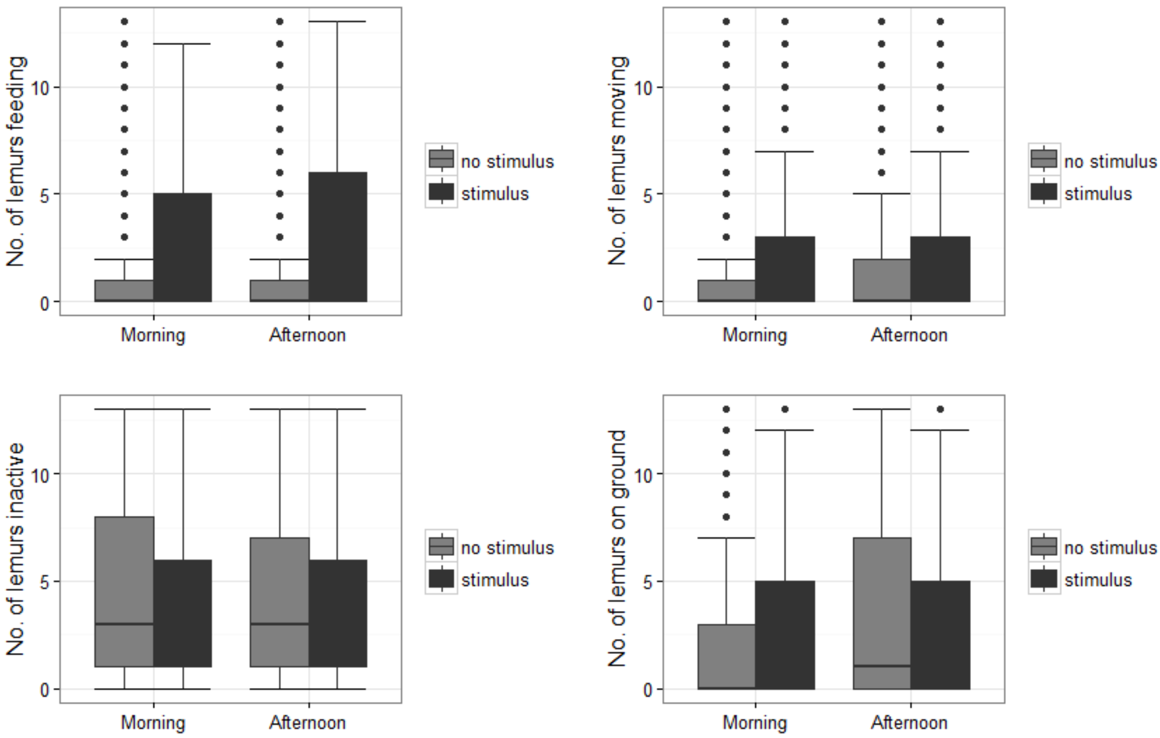


Figure 3.2. The effect of the interactions between time of day and stimulus on the following recorded behaviours; feeding, locomotion, inactivity and 'on ground'. The horizontal lines are the limits of the nominal range of the data inferred from the upper and lower quartiles, the points that fall outside this range are denoted as circles.

Table 3.4. Results from GEE test, showing estimated parameters and p-values for each statistically significant covariate (p<0.05)

Behaviors	Feeding	Grooming	Hut	Affiliative	NV	Locomotion	Inactive	Up/down
Model Intercept	0.338 (0.493)	-2.288 (<0.001)	1.807 (<0.001)	2.129 (<0.001)	0.370 (0.383)	-1.386 (<0.001)	0.713 (0.004)	-0.435 (0.2)
Environmental variables								
Time	↓ -0.458 (0.006)	-	↑0.534 (0.009)	-	-	-	↑0.149 (0.048)	↑0.458 (<0.001)
Season	-	↑ 0.104 (0.025)	↓ -0.828 (<0.001)	↑ 0.1418 (0.003)	-	-	↑ 0.192 (<0.001)	↓ 0.250 (<0.001)
Weather	-	↑ 0.245 (<0.001)	↓ -0.502 (<0.001)	-	↓ -0.086 (0.005)	↑ 0.072 (0.005)	-	↑0.032 (<0.001)
Stimulus	↑ 0.572 (<0.001)	-	-	↓ -1.087 (<0.001)	-	↑ 0.940 (<0.001)	-	↑0.041
Location	-	-	NA	↓ -0.317 (<0.001)	-	-	-	-
Visitor variables								
Visitor number	-	-	-	-	-	↑0.031 (0.009)	-	↑0.021 (0.037)
Visitor behaviour	-	-	-	-	-	-	-	-
Baby stroller	-	↓ -0.660 (0.011)	-	-	-	↓ -0.381 (0.024)	-	-
Interactions								
Time:pram	-	↑ 0.420 (0.005)	-	-	-	-	-	-
Time:stimulus	↑ 0.231 (0.004)	-	-	-	-	↓ -0.241 (0.006)	↓ -0.164 (<0.001)	↓ 0.282 (<0.001)
Time:visitor no.	-	-	-	-	-	-	-	-
Location:visitor behaviour	-	-	NA	-	-	-	-	-

Statistical analysis began with the baseline or the lowest category of a variable and was then compared against the higher categories (see Table 2 for reference categories). Arrows refer to a statistically significant increase (↑) or decrease (↓) in behaviour. Hut behaviour could only occur in one location.

3.3.3 Behavioural diversity

Instantaneous 'crowd size'

The Spearman rank correlation test revealed a very weak association between the number of visitors present at each scan 'crowd size' and the behavioural diversity level at each scan for all observations (r_s=0.056, p=<0.001).

Daily total 'visitor frequency'

The Spearman rank correlation test indicated a weak negative association between total number of visitors per day 'visitor frequency' and mean daily behavioural diversity level (r_s= -0.158; p=0.006). As daily number of visitors or 'visitor frequency' increased, behavioural diversity of the lemur group decreased.

3.3.4 Visitor-lemur interactions

Visitors were present during 45.9% (n=5512) of the observations. The number of visitors present ranged from 1 – 65. In only 76 cases (1.38%) did visitors attempt to interact with the lemurs and in only 96 (1.03%) cases did the lemurs direct behaviours at the public. In 20 of the 96 cases (21%) when lemurs directed behaviour at the public there was no reciprocal action from the visitors. Out of the 76 times that visitors attempted to interact with the lemurs; 0.04% (n=3) of the interactions were approaches to the lemurs, 59.21% (n=45) of the interactions were attempts to feed the lemurs, and 36.84% (n=28) of the interactions were attempts to frighten the lemurs. Because no overall effect of visitor behaviour (as a binary variable) on lemurs' behaviour was found (Table 3.4), Fisher's exact test was used to isolate effects of specific visitor behaviours on lemur actions. A significant difference between visitor behaviour and lemur action (p<0.001) was detected. However, after the Bonferroni correction was applied (at 0.05/12 α=0.004), none of the comparisons between visitor behaviour and lemur action remained significant (Figure 3.3 and Table 3.5).

Table 3.5. Results of Fisher's exact test comparing visitor behaviour and lemur action.

	Lemur Action			
Visitor Behaviour	No response n = 48	Approach n = 11	Food n = 9	Retreat n = 8
Approach n = 3	Z = -1.09 χ^2 = 1.19 p = 0.276 n = 1	Z = 0.95 χ^2 = 0.90 p = 0.342 n = 1	Z = -.65 χ^2 = 0.42 p = 0.516 n = 0	Z = 1.31 χ^2 = 1.72 p = 0.190 n = 1
Food n = 45	Z = -2.14 χ^2 = 4.58 p = 0.324 n = 24	Z = 2.31 χ^2 = 5.34 p = 0.021 n = 10	Z = 2.65 χ^2 = 7.02 p = 0.008 n = 9	Z = -2.08 χ^2 = 4.33 p = 0.038 n = 2
Frighten n = 28	Z = 2.62 χ^2 = 6.86 p = 0.009 n = 23	Z = -2.74 χ^2 = 7.51 p = 0.006 n = 0	Z = -2.44 χ^2 = 5.95 p = 0.015 n = 0	Z = 1.59 χ^2 = 2.53 p = 0.112 n = 5

α = 0.004 after Bonferroni correction

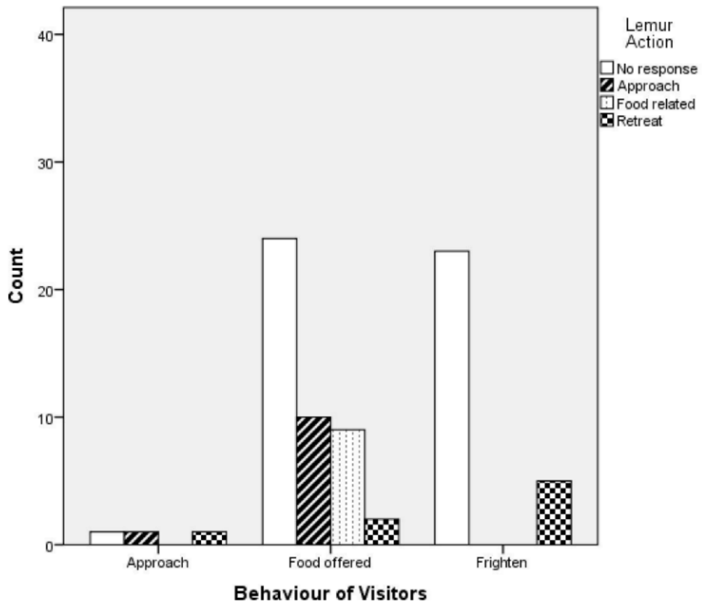


Figure 3.3. Total count of lemurs' actions (no response, approach, food related and retreat) during three different visitor behaviours (approach, food offered and frighten).

3.4 Discussion

Common environmental and visitor variables within the zoo affect the behaviour, position and behavioural diversity level of a free-ranging ring-tailed lemur group to varying degrees. Previous research has shown that time of day, season and weather affect free-ranging ring-tailed lemur behaviour (Ramsay, 1995) and these results support that. In both studies lemurs were more active during drier, warmer, lighter conditions, and conversely lemurs spent more time in their hut and not visible during colder, wetter, darker conditions (later in the day). Ramsay (1995) also reported an increase in feeding/foraging due to seasonality. Here, feeding was the only behaviour not influenced by weather or season, though this is probably because the current data were collected from March – October when food was plentiful. However, the current results concur with Ramsay (1995) and studies from the wild (Jolly, 1966b) that intense feeding/foraging is likely to occur in the morning.

The increase in inactivity, grooming and affiliative behaviour and the absence of intra-group aggression observed in this study from March – October indicates that the lemurs have a diverse repertoire of behaviour when resources are not limited. Additionally, the increase in affiliative behaviour observed in this study coincides with the early stage of lemurs' natural breeding period at Fota Wildlife Park, which has also been observed in wild populations (Jolly, 1966b). The breeding period at Fota occurs approximately six months after the natural breeding period of wild lemurs in the Southern hemisphere, as in expected in Northern hemisphere populations (Parga and Lessnau, 2005). Wild lemurs are known to exhibit sexual consortships during the breeding season, though they also become more aggressive during mating (Jolly, 1966b; Sauther et al., 1999), which was not observed here.

It was discovered that, in general, behaviour does not vary with location at Fota Wildlife Park. Therefore, it is unlikely that the group is travelling to certain locations to exploit a specific food source, as lemurs in the wild are known to do (Sauther et al., 1999). This is probably due to the abundance of food available to the lemurs at Fota Wildlife Park. The nature of the zoo means that even for free-ranging animals, resources will never truly be scarce, which inherently limits certain behaviours and potential environmental stressors (Parga and Lessnau, 2005). Though it is difficult to directly compare Fota's free-ranging lemur group behaviour to wild lemur behaviour because of differences in methodology, similarities in behaviour between free-ranging groups in captivity and wild lemurs in Madagascar are known to exist (Keith-Lucas et al., 1999). Here it is suggested that the behaviour patterns of the free-ranging lemurs at Fota Wildlife Park are similar to lemurs in the wild when food is not scarce. Intra-group aggression, which can occur when resources are limited in wild populations (Budnitz and Dainis, 1975; Sauther et al., 1999), was not observed at Fota, nor were any stereotypies, sometimes displayed by traditionally caged captive lemurs (Tarou et al., 2005; Dishman et al., 2009). Additionally, the number of plant species foraged and the daily foraging pattern observed at Fota Wildlife Park is similar to wild populations. The free-ranging lemur group at Fota has been observed to forage 20 different plant species (Ramsay, 1995), 17 species were foraged at another free-range environment (Keith-Lucas et al., 1999) and 24 in the wild (Jolly, 1966b). The current study observed the lemurs between 09:30h and 17:30h; however, during the summer months the lemurs might continue to be active later in the evening and future work should include longer daily observation periods and, if possible, observations when resources are limited to capture the full repertoire of lemur behaviour.

One of the complexities of zoo research can be the sudden and unexpected appearance of staff or a zoo vehicle. Many researchers have ceased observations because of the obvious change in an animal's behaviour at the appearance of an unexpected stimulus. However, here, it was decided to use this information in order to quantify one of the most frequently occurring variables of the zoo setting on animals' behaviour. The presence of a zoo stimulus was associated with an increase in feeding, locomotion and being on the ground and a decrease in affiliative behaviour. The animals may associate zoo staff and vehicles with food, since when a stimulus occurs, locomotion and feeding increase, as lemurs presumably run to investigate and are then fed. The decrease in affiliative behaviour when a stimulus occurs is probably because of the increase in feeding and locomotion. An interaction effect of time and stimulus may indicate lemurs' awareness of the husbandry routine and zoo schedule. More research is needed to clarify this and tease out lemur reaction to different types of zoo stimuli at different times of day.

In conjunction with considering environmental zoo variables visitor-related variables were also considered. Like Choo et al. (2011), several different aspects of visitors including number, behaviour and the presence of a baby stroller were investigated. Visitor number had a limited influence on lemur behaviour, which is similar to what other studies on free-ranging species report (Choo et al. 2011; Sherwen et al. 2015). As visitor number increased, locomotion and 'on the ground' increased, this is supportive of the visitor attraction hypothesis (Hosey, 2000). The moving, visible animals probably attracted a larger crowd. The fact that the lemurs were visible on the ground suggests that they were not frightened of visitors, though it is possible that they were retreating. However, results from this study on lemur-visitor interactions indicate that the lemurs rarely retreat. Manna et al. (2007) found little effect on lemur behaviour or welfare in a visitor walk through exhibit, but like the present study, they observed an increase in terrestrial locomotion when visitors were present. Hosey et al. (2016) reported no correlation between increased agonistic wounding rate in ring-tailed lemurs and increased visitor numbers in a walk-through exhibit. Conversely, a study within a traditional enclosure, with and without visitors present, found that agonistic behaviour increased, and inactivity and grooming decreased when visitors were present, which again indicates that the animals' housing system and ability to retreat is of significant importance (Chamove et al. 1988).

In the present study, it was found that high daily total visitor numbers were associated with a slight decrease in behavioural diversity level, whereas there was almost no association between instantaneous behavioural diversity level and crowd size. This offers tentative evidence that lemurs are perhaps stimulated or not bothered by intermittent large groups, but when there are continual large groups of visitors (high daily totals) behavioural diversity is reduced, which could indicate an upper limit of tolerance for visitors, which has been found in some captive bird species (Nimon and Dalziel, 1992; Collins and Marples, 2015).

Previous studies have reported that free-ranging monkeys are adept at jumping on and obtaining food from baby strollers (Jens et al., 2012; Price et al., 2012). At Fota, the presence of a baby stroller was associated with a decrease in grooming, as well as a decrease in locomotion. This suggests that lemurs do not run towards or away from strollers, but may stop their usual behaviours when they are present. It may be that the lemurs are anticipating food, though this is unclear, as feeding was not observed to increase when a baby stroller was present. In fact, the presence of a stroller is the only variable that was associated with a statistically significant reduction in locomotion, whereas a zoo 'stimulus' caused an increase in locomotion, which is evidence that the lemurs may discriminate between visitors and staff (Hosey 2008; Hosey et al. 2013). More research is needed to understand the impact of strollers on free-ranging primates. Results indicate a change in lemur behaviour occurred when a stroller was present, but the implications of that are ambiguous.

When visitors engaged in behaviours that were not compliant with the park's rules, there was no effect on lemur behaviour, but in order to further disentangle visitor-lemur interactions in the zoo setting, specific visitor behaviours and lemur actions were analysed. After post hoc testing, none of the comparisons between visitor behaviour and lemur action were statistically significant. However, some interactions between lemurs and visitors were close to significance so, in order to avoid a type II error, they are briefly considered here. If visitors exhibited a negative action towards the lemurs (frighten), the lemurs' most common action was not to respond; however, there is also evidence that sometimes they retreated, but they did not approach or receive food when disturbed. When visitors offered food to the lemurs, again the lemurs did not often respond; however, they were sometimes observed to receive food and approach visitors, but rarely retreat. It has been suggested that food solicitation by animals is indicative of a lack of fear towards visitors (Choo et al. 2011), which these results support.

Overall results indicate that the ring-tailed lemurs at Fota Wildlife Park have probably habituated to the presence of visitors and are not suffering from diminished welfare. Even though the free-range environment offers the opportunity for intense visitor–animal interactions these rarely occur and when they do there is no indication that the lemurs are distressed. Furthermore, the present results, based on these behaviour data, show that if lemurs are disturbed or frightened by visitors they can respond by running away, which allows them the opportunity to give a species-typical response to a stressful situation, which may diminish the stress of captivity (Carlstead and Shepherdson, 2000). Morgan and Tromborg (2007) give several reasons for stress in captive animals, including limited retreat space and forced proximity to humans, but at Fota Wildlife Park the lemurs can retreat at will and their movement is in no way restricted.

Visitors are especially drawn to the active, charismatic, free-ranging lemurs at Fota Wildlife Park (T. Power, primate keeper, pers. comm., July 27, 2016) and, similar to Jones et al. (2016), no evidence of compromised lemur welfare during animal-visitor interactions was found, which may indicate that lemurs could be a useful species for enhancing educational opportunities and developing personal connections with animals. In fact, Kreger and Mench (1995, p. 155) state that '[the] human-animal bond may be the most effective way for the zoo to communicate its educational messages to the visitor'. Previous research from early animal-visitor interaction studies indicates that not only do visitors desire a response from zoo animals, but that they would also like a personal connection with wild animals; zoos may facilitate this need through animal-visitor feeding experiences, which may lead to better attitudes towards individual animals and species (Kreger and Mench, 1995). However, Jones et al. (2016) issue the caveat that these types of animal-visitor interactions should focus on conservation and education, not entertainment, yet there is little evidence from current interaction experiences to show how visitors' attitudes and behaviour toward conservation are influenced by interactive experiences. Since these types of interactions are becoming more popular in zoos, more research is needed to elucidate the effect that the interactions have on both the visitors and the animals. Combining visitor-animal interactions with an educational experience, such as interpretative material and staff talks, may enhance visitor learning and improve animal welfare (Kratochvil and Schwammer 1997; Fernandez et al., 2009; Moss and Esson, 2010; Mun et al., 2013), but again more research is needed to clarify which animals are most suitable for interactions and if visitor learning is indeed affected by close interactions.

The current study has only considered one species in one environment and results are not applicable to all captive lemurs; further work on more species in more institutions with varying exhibit types is needed. However, certain species that have repeatedly not shown an adverse reaction to visitors or interactions with them under several different circumstances and that are known to have developed positive HARs could be beneficial in promoting conservation education within the zoo (Fernandez et al., 2009; Hosey and Melfi, 2015; Jones et al., 2016). The free-range environment at Fota Wildlife Park, in which the lemurs can control interactions with visitors, in combination with the ability to exhibit species-typical behaviour patterns and their natural adaptability, has probably contributed to the lemurs' habituation to humans, lack of visitor induced stress and positive welfare.

3.5 Conclusions

1. This study found that free-ranging ring-tailed lemur behaviour is affected by time of day, season and weather. Generally, the lemurs are more active in drier, warmer conditions.
2. The Fota lemurs exhibit similar feeding behaviour patterns to wild lemurs, when resources are not limited.

3. Relatively minor effects of visitors on the free-ranging animals were detected. It was found that the animals have largely habituated to the presence of visitors, and that they benefit from being able to retreat from visitors.
4. There were relatively few animal-visitor interactions; however, continuous large crowds may lead to a reduction in behavioural diversity.
5. Ring-tailed lemurs are likely to do well in a free-range display, but it is essential that their reaction to environmental and visitor variables is investigated and understood.

3.6 References

Altmann, J. (1974). Observational study of behaviour: sampling methods. *Behaviour*, 49(3), 227-266.

Beasley, T. M. & Schumacker, R. E. (1995). Multiple regression approach to analyzing contingency tables: Post hoc and planned comparison procedures. *The Journal of Experimental Education*, 64(1), 79-93.

Birke, L. (2002). Effects of browse, human visitors, and noise on the behaviour of captive orang-utans. *Animal Welfare*, 11, 189-202.

Budnitz, N. & Dainis, K. (1975). *Lemur catta*: Ecology and behaviour. In: I. Tattersall & R. W. Sussman (Eds.), Lemur biology. Springer US. p. 219-235.

Carder, G. & Semple, S. (2008). Visitor effects on anxiety in two captive groups of western lowland gorillas. *Applied Animal Behaviour Science*, 115, 211-220.

Carlstead, K. & Shepherdson, D. (2000). Alleviating stress in zoo animals with environmental enrichment. In: G. P. Moberg & J. A. Mench (Eds.), *The biology of animal stress: Basic principles and implications for animal welfare*. CABI. p. 337-354.

Chamove, A. S., Hosey, G. R. & Schaetzel, P. (1988). Visitors excite primates in zoos. *Zoo Biology*, 7(4), 359-369.

Choo, Y., Todd, P. A. & Li, D. (2011). Visitor effects on zoo orangutans in two novel, naturalistic enclosures. *Applied Animal Behaviour Science*, 133(1), 78-86.

Clark, F. E., Fitzpatrick, M., Hartley, A., King, A. J., Lee, T., Routh, A., Walker, S. L.& George, K. (2012). Relationship between behavior, adrenal activity, and environment in zoo-housed western lowland gorillas (*Gorilla gorilla gorilla*). *Zoo Biology*, 31(3), 306-321.

Clark, F. E. & Melfi, V. A. (2012). Environmental enrichment for a mixed-species nocturnal mammal exhibit. *Zoo Biology*, 31(4), 397-413.

Claxton, A. M. (2011). The potential of the human–animal relationship as an environmental enrichment for the welfare of zoo-housed animals. *Applied Animal Behaviour Science*, 133(1), 1-10.

Clayton, S., Fraser, J. & Saunders, C. D. (2009). Zoo experiences: Conversations, connections, and concern for animals. *Zoo Biology*, 28(5), 377-397.

Coe, J. C. (1989). Naturalizing habitats for captive primates. *Zoo Biology*, 8(S1), 117-125.

Collins, C. K. & Marples, N. M. (2015). Zoo Playgrounds: A Source of Enrichment or Stress for a Group of Nearby Cockatoos? A Case Study. *Journal of Applied Animal Welfare Science*, 18(4), 375-387.

Collins, C. K., Quirke, T., Overy, L., Flannery, K. & O'Riordan, R. (2016). The effect of the zoo setting on the behavioural diversity of captive Gentoo penguins and the implications for their educational potential. *Journal of Zoo and Aquarium Research*. 4(2), 85-90.

Diggle, P. J., Liang, K. Y. & Zeger, S. L. (1995). Analysis of Longitudinal Data. Clarendon, Oxford.

Dishman, D. L., Thomson, D. M. & Karnovsky, N. J. (2009). Does simple feeding enrichment raise activity levels of captive ring-tailed lemurs (*Lemur catta*)? *Applied Animal Behaviour Science*, 116(1), 88-95.

Estep, D. Q. & Hetts, S. (1992). Interactions, relationships and bonds: the conceptual basis for scientist–animal relations. In H. E. Davis & D. A. Balfour (Eds.), *The Inevitable Bond: Examining Scientist–Animal Interactions*. Cambridge University Press. p. 6-26.

Fernandez, E. J., Tamborski, M. A., Pickens, S. R. & Timberlake, W. (2009). Animal–visitor interactions in the modern zoo: Conflicts and interventions. *Applied Animal Behaviour Science*, 120(1), 1-8.

Finlay, T., James, L. R. & Maple, T. L. (1988). People's perceptions of animals the influence of zoo environment. *Environment and Behaviour*, 20(4), 508-528.

Foley, S. (2016). A Comparative Study on the Behaviour of Free Ranging Ring-Tailed Lemurs (*Lemur catta*) at Fota Wildlife Park, Cork. [Final Year Research Thesis]. Cork: University College Cork.

Glatston, A. R., Geilvoet-Soeteman, E., Hora-Pecekand, E. & Van Hooff, J. A. R. A. M. (1984). The influence of the zoo environment on social behaviour of groups of cotton-topped tamarins, (*Saguinus oedipus oedipus*). *Zoo Biology*, 3, 241-253.

Gould, L., Sussman, R. W. & Sauther, M. L. (1999). Natural disasters and primate populations: the effects of a 2-year drought on a naturally occurring population of ring-tailed lemurs (*Lemur catta*) in southwestern Madagascar. *International Journal of Primatology*, 20(1), 69-84.

Hosey, G. R. (2000). Zoo animals and their human audiences: what is the visitor effect? *Animal Welfare*, 9, 343-357.

Hosey, G. R. (2005). How does the zoo environment affect the behaviour of captive primates? *Applied Animal Behaviour Science*, 90(2), 107-129.

Hosey, G. R. (2008). A preliminary model of human–animal relationships in the zoo. *Applied Animal Behaviour Science*, 109(2), 105-127.

Hosey, G., Birke, L., Shaw, W. S. & Melfi, V. (2018). Measuring the Strength of Human–Animal Bonds in Zoos. *Anthrozoös*, 31(3), 273-281.

Hosey, G. R. & Melfi, V. A. (2014). Human-animal interactions, relationships and bonds: a review and analysis of the literature. *International Journal of Comparative Psychology*, 27(1). 117-142.

Hosey, G. R. & Melfi, V. A. (2015). Are we ignoring neutral and negative human–animal relationships in zoos? *Zoo Biology*, 34(1), 1-8.

Hosey, G. R., Melfi, V. A. & Pankhurst, S. (2013). Zoo animals: behaviour, management, and welfare. Oxford University Press.

Hosey, G., Melfi, V., Formella, I., Ward, S. J., Tokarski, M., Brunger, D., Brice, S. & Hill, S. P. (2016). Is wounding aggression in zoo-housed chimpanzees and ring-tailed lemurs related to zoo visitor numbers? *Zoo Biology*, *35*(3), 205-209.

IUCN Red List. http://www.iucnredlist.org/details/11496/0. Last date accessed June 8, 2018.

Jens, W., Mager-Melicharek, C. A. X. & Rietkerk, F. E. (2012). Free-ranging New World primates in zoos: cebids at Apenheul. *International Zoo Yearbook*, 46 (1), 137-149.

Jolly, A. (1966a). Lemur social behaviour and primate intelligence. *Science*, 153(3735), 501-506.

Jolly, A. (1966b). Lemur Behaviour: A Madagascar Field Study. The University of Chicago Press, Chicago, IL, p. 187.

Jones, H., McGregor, P. K., Farmer, H. L. & Baker, K. R. (2016). The influence of visitor interaction on the behaviour of captive crowned lemurs (*Eulemur coronatus*) and implications for welfare. *Zoo Biology*, 35(3), 222-227.

Keith-Lucas, T., White, F. J., Keith-Lucas, L. & Vick, L. G. (1999). Changes in behaviour in free-ranging *Lemur catta* following release in a natural habitat. *American Journal of Primatology*, 47(1), 15-28.

Kratochvil, H. & Schwammer, H. (1997). Reducing acoustic disturbances by aquarium visitors. *Zoo Biology*, 16(4), 349-353.

Kreger, M. D. & Mench, J. A. (1995). Visitor–animal interactions at the zoo. *Anthrozoös*, 8, 143–158.

Kuhar, C. W. (2008). Group differences in captive gorillas’ reaction to large crowds. *Applied Animal Behaviour Science*, 110(3), 377-385.

LaFleur, M., Clarke, T. A., Reuter, K. & Schaeffer, T. (2016). Rapid decrease in populations of wild ring-tailed lemurs (*Lemur catta*) in Madagascar. *Folia Primatologica*, 87(5), 320-330.

Manna, D., Rodeano, M. & Ferrero, E. A. (2007). A Lemur Mixed Exhibit at Parco Zoo Punta Verde, Italy. *International Zoo News*, 361, 452-457.

McDaniel, L. & Henderson, N. (2013). geeM: Fit Generalized Estimating Equations. URL http://CRAN.R-project.org/package=geeM. R package version 0.06. p.181.

Mitchell, G., Herring, F., Obradovich, S., Tromborg, C., Dowd, B., Neville, L. E. & Field, L. (1991). Effects of visitors and cage changes on the behaviors of mangabeys. *Zoo Biology*, 10(5), 417-423.

Mitchell, G., Tromborg, C. T., Kaufman, J., Bargabus, S., Simoni, R. & Geissler, V. (1992). More on the 'influence' of zoo visitors on the behaviour of captive primates. *Applied Animal Behaviour Science*, 35(2), 189-198.

Morgan, K. N. & Tromborg, C. T. (2007). Sources of stress in captivity. *Applied Animal Behaviour Science*, 102(3), 262-302.

Moss, A. & Esson, M. (2010). Visitor interest in zoo animals and the implications for collection planning and zoo education programmes. *Zoo Biology*, 29(6), 715-731.

Mun, J. S. C., Kabilan, B., Alagappasamy, S. & Guha, B. (2013). Benefits of naturalistic free-ranging primate displays and implications for increased human-primate interactions. *Anthrozoös* 26:13–26.

Murphy, A. J., Ferguson, B. & Gardner, C. J. (2017). Recent Estimates of Ring-Tailed Lemur (*Lemur catta*) Population Declines are Methodologically Flawed and Misleading. *International Journal of Primatology*, 38(4), 623-628.

Myers, O. E., Saunders, C. D. & Birjulin, A. A. (2004). Emotional dimensions of watching zoo animals: An experience sampling study building on insights from psychology. *Curator: The Museum Journal*, 47(3), 299-321.

Nimon, A. J. & Dalziel, F. R. (1992). Cross-species interaction and communication: a study method applied to captive siamang (*Hylobates syndactylus*) and long-billed corella (*Cacatua tenuirostris*) contacts with humans. *Applied Animal Behaviour Science*, 33(2), 261-272.

Parga, J. A. & Lessnau, R. G. (2005). Female age-specific reproductive rates, birth seasonality, and infant mortality of ring-tailed lemurs on St. Catherine's Island: 17-year reproductive history of a free-ranging colony. *Zoo Biology*, 24(4), 295-309.

Patrick, P. G., Matthews, C. E., Ayers, D. F. & Tunnicliffe, S. D. (2007). Conservation and Education: Prominent Themes in Zoo Mission Statements. *The Journal of Environmental Education*, 38(3), 53–59.

Price, E. C., Ashmore, L. A. & McGivern, A. M. (1994). Reactions of zoo visitors to free-ranging monkeys. *Zoo Biology*, 13(4), 355-373.

Price, E. C., Wormell, D., Brayshaw, M., Furrer, S., Heer, T. & Steinmetz, H. W. (2012). Managing free-ranging callitrichids in zoos. *International Zoo Yearbook*, 46(1), 123-136.

Rabb, G. B. (2004). The evolution of zoos from menageries to centers of conservation and caring. *Curator: The Museum Journal*, 47(3), 237-246.

Ramsay, N. F. (1995). The influence of environmental constraints on aspects of the eco-ethology of the lemurs (*Lemur catta*) Linnaeus 1785 and (*Eulemur fulvus mayottensis*) Schlegel 1866 in wild and captive environments. [PhD Dissertation]. Cork: University College Cork.

Reade, L. S. & Waran, N. K. (1996). The modern zoo: How do people perceive zoo animals? *Applied Animal Behaviour Science*, 47(1-2), 109-118.

Russow, L. M. (2002). Ethical implications of the human-animal bond in the laboratory. *ILAR Journal*, 43(1), 33-37.

Sauther, M. L., Sussman, R. W. & Gould, L. (1999). The socioecology of the ring-tailed lemur: thirty-five years of research. *Evolutionary Anthropology Issues News and Reviews*, 8(4), 120-132.

Shannon, C. E. & Weaver, W. (1949) *The Mathematical Theory of Information.* University of Illinois Press, Urbana, IL.

Sherwen, S. L., Hemsworth, P. H., Butler, K. L., Fanson, K. V. & Magrath, M. J. (2015). Impacts of visitor number on Kangaroos housed in free-range exhibits. *Zoo Biology*, 34(4), 287-295.

Skibins, J. C. & Powell, R. B. (2013). Conservation caring: Measuring the influence of zoo visitors' connection to wildlife on pro-conservation behaviours. *Zoo Biology*, 32(5), 528-540.

Species 360. https://www.species360.org/. Last date accessed August 22, 2018.

Stevens, J., Thyssen, A., Laevens, H. & Vervaecke, H. (2013). The influence of zoo visitor numbers on the behaviour of harbour seals (*Phoca vitulina*). *Journal of Zoo and Aquarium Research*, 1(1), 31-34.

Stoinski, T. S., Jaicks, H. F. & Drayton, L. A. (2012). Visitor effects on the behaviour of captive western lowland gorillas: the importance of individual differences in examining welfare. *Zoo Biology*, 31(5), 586-599.

Tarou, L. R, Bloomsmith, M. A. & Maple, T. L. (2005). Survey of stereotypic behaviour in prosimians. *American Journal of Primatology*, *65*(2), 181-196.

Wells, D. L. (2005). A note of the influence of visitors on the behaviour and welfare of zoo-housed gorillas. *Applied Animal Behaviour Science*, 93, 13-17.

Wood, W. (1998). Interactions among environmental enrichment, viewing crowds, and zoo chimpanzees (*Pan troglodytes*). *Zoo Biology*, 17, 211-230.

Zuur, A. F, Ieno, E. N. & Elphick, C. S. (2010). A protocol for data exploration to avoid common statistical problems. *Methods in Ecology and Evolution*, 1(1), 3-14.

Chapter 4

The effect of the zoo setting on the behavioural diversity of captive Gentoo penguins (*Pygoscelis papua*) and the implications for their educational potential.

A modified version of this chapter has been published in The Journal of Zoo and Aquarium Research in the following form; Collins, C., Quirke, T., Overy, L., Flannery, K., O'Riordan, R. 2016. The effect of the zoo setting on the behavioural diversity of captive Gentoo penguins and the implications for their educational potential. Journal of Zoo and Aquarium Research, Vol. 4, Issue 2, p. 85-90. See Appendix 6.

© Dingle Ocean World (Mara Beo)

Abstract

Investigations into the effect of the captive environment on zoo and aquarium-housed animals is now a well-established area of research; yet little attention is given to the effect of these animals on zoo visitors. It has been suggested that some animals have a greater ability to attract and thus educate visitors, but there is a dearth of information in this area. Furthermore, before a captive species' educational potential can be determined, its response to the zoo environment should be investigated to ensure its welfare. The current study first considers the effect of visitor presence and environmental enrichment on the behavioural diversity levels of aquarium-housed Gentoo penguins (*Pygoscelis papua*), with particular attention given to pool-use and nesting behaviour. Then, based on the animals' response to the visitors and enrichment, the educational potential of the penguin group is considered. Data were obtained through scan samples taken throughout the breeding season. Results indicate that visitor number affects behavioural diversity levels, with higher numbers of visitors associated with greater behavioural diversity and pool use by penguins. However, neither visitor behaviour nor enrichment appear to affect behavioural diversity. Nesting behaviour was not affected by any of the variables that were tested. Based on these results it is concluded that the penguins at this aquarium have a high educational potential. The results of this study suggest that future research should consider the use of interactive enrichment and how captive penguins may further enhance visitor learning.

4.1 Introduction

The effect of the zoo environment on captive animals has generated considerable literature in recent years, with visitor presence and environmental enrichment recognised as two factors that affect a species' wellbeing in the zoo (Swaisgood and Shepherdson, 2005; Hosey, 2008). However, there has been little attention given to the educational value of animals held in zoos, even though education is often one of the justifications for keeping animals in captivity (Moss and Esson, 2010; Jensen, 2014). Moss and Esson (2010) propose that zoos should consider which animals to display based on their educational value, and that those species that visitors are most interested in and spend the most time watching, may offer the best learning potential. However, it is also essential to consider the response of that species to the zoo environment, including visitors, as it would be contrary to positive welfare to display animals that attract large crowds, if these animals show an adverse response to visitors. Although the IUCN (International Union for the Conservation of Nature) Red List has recently downlisted Gentoo penguins in the wild as 'least concern' because of an increase in their population, they are still vulnerable to environmental change, marine traffic and tourist disturbance during breeding (IUCN, 2017). Therefore, zoos may be significantly important for the survival of this species. Gentoo penguins are already a commonly held species by zoos and aquariums, with 36 institutions world-wide keeping them (Species 360, 2018).

Little is known about the relationship between captive penguins and zoo visitors. Ozella et al. (2015) report that captive African penguins in close proximity to human bathers, used their pool less early in the season, especially when large numbers of bathers were present, but eventually habituated to the humans, and pool use was no longer affected. Hosey (2008) summarised a series of unpublished reports which investigated the effect of visitors on captive penguin behaviour and concluded that there were no consistent trends in the research. Limited research on other species of birds in captivity has found that cockatoos may either find visitors stimulating or show no behavioural response to visitors (Nimon and Dalziel, 1992; Collins and Marples, 2015).

In wild populations of penguins, there is evidence that the birds are disturbed by the presence of humans (see Carney and Sydeman, 1999; Seddon and Ellenberg, 2008; Steven et al., 2011 for reviews), though, there are conflicting results between studies.

Culik and Wilson (1991) discovered that visits by tourists at Admiralty Bay were associated with a heart rate increase of 50% in Adélie penguins (*Pygoscelis adeliae*) during the breeding season, causing the authors to conclude that tourism negatively affects breeding colonies of penguins. Additionally, Wilson et al. (1991) suggested that human presence, in conjunction with airplane disturbance, is compromising the population growth of Adélie penguins, with some penguins abandoning nest or chicks when humans approach. In contrast, Cobley and Shears (1999) reported that visits by tourists to Gentoo penguins at Port Lockroy, Goudier Island, Antarctica were unlikely to interfere with breeding success or population growth. Similarly, Yorio and Boersma (1992) found that Magellanic penguins (*Spheniscus magellanicus*) did not abandon their nests when humans approached.

Nimon et al. (1995) used an artificial egg to measure nesting penguin heart rate, thus limiting human handling. They reported that there was no difference in the heart rate of Gentoo penguins in the absence or presence of one person from a distance of three meters (Nimon et al., 1995), but that a sudden movement from the same distance resulted in brief heart rate increases of 50%, leading the authors to conclude that penguins may be affected by the type of behaviour a person does when observing penguins and not just their presence (Nimon, et al., 1996). Additionally, Nimon et al. (1995) concluded that the technique used to tag penguins by Culik and Wilson (1991) caused a learned response to fear humans, and thus penguins reacted with fear (i.e. increased heart rate) when humans were present. Culik and Wilson (1995) countered that inconsistent methodology, inter- and intra-specific differences and different stages of breeding were responsible for the contradictory results of these studies.

More recent studies confirm a trend that tourists may disturb penguins in regard to breeding success, fledging weight, foraging access and energy expenditure in a variety of species (e.g. McClung et al., 2004; Burger and Gochfield, 2007; Ellenberg et al., 2007); however, species type, age, health, breeding status, as well as, previous history and exposure to tourists are likely to be important components in penguins' responses (Seddon and Ellenberg, 2008; Villanueva et al., 2012). These responses and limitations reflect those of animal-visitor studies in captivity, with the variables of the zoo setting, species type and previous experience with visitors often cited as contributing factors in visitor effect studies (Hosey, 2008, 2013; Stoinski et al., 2012). Regardless, there is sufficient evidence that penguins in the wild are disturbed by tourists to warrant further investigation of the effect of zoo visitors on their captive counterparts.

Environmental enrichment is a practice used by zoos to improve the welfare of captive animals by providing environmental stimuli, with one of the major goals being to promote species-typical behaviour in captivity (Mellen and MacPhee, 2001). It has even been suggested that visitors and staff can act as an enriching stimulus for animals in captivity (Morris, 1964; Hosey, 2000; Claxton, 2011), though Hosey (2008, p.110) cautioned that visitor presence ‘mostly supported the stressful hypothesis, with some support for the hypothesis that audiences could under some circumstances be enriching’. Carlstead and Shepherdson (2000) reported that enrichment may be useful in alleviating stress in captive animals, and some studies have used enrichment specifically to alleviate visitor induced stress. The majority of the latter studies focus on primates and results were variable, but tend to indicate that the provision of enrichment during periods of high visitor density was associated with a reduction of behaviours often correlated with visitor induced stress (Birke, 2002; Carder and Semple, 2008; Clarke et al., 2012). Limited previous research on enrichment for captive penguins has produced contradictory results. Clarke (2003) found that enrichment devices did not have an effect on penguin pool use, while Larsson (2012) report that increased pool use in penguins was likely associated with the introduction of enrichment.

Yet, increased animal activity is often a consequence of enrichment (Margulis et al., 2003), and previous studies confirm that zoo visitors show more interest in and learn more from active animals (Bitgood et al., 1988; Margulis et al., 2003). If there are no welfare implications, having animals engage with enrichment when visitors are present may increase the educational potential of that animal (Moss and Esson, 2010). However, before employing this husbandry approach, the animals’ reaction to visitors and enrichment should be evaluated. The objective of this research was to examine:

1) The behavioural diversity of a group of captive Gentoo penguins (*Pygoscelis papua*) during different visitor and enrichment conditions.

2) If two specific behaviours (Pool-use and nesting) were affected by different visitor and enrichment conditions.

3) A range of penguin behaviours during different visitor and enrichment conditions.

4.2 Methodology

Study site, animals and enclosure

Data were collected on captive Gentoo penguins in Dingle Aquarium, County Kerry, Ireland between March and August 2014. At that time, Dingle Aquarium had 12 Gentoo penguins, eight females and four males, all born in captivity. During the study period, all penguins participated in nesting and breeding activity, resulting in the production of 13 eggs and one live chick, which was the first penguin chick to be born at the aquarium. The penguin enclosure at the aquarium is a purpose-built indoor facility operational since 2011. It consists of a 120,000l pool with a land surface area of 35m^2 and a water surface area of 30m^2. There is a glass wall, interspersed with artificial rock structures, of approximately 15.6m separating the penguins from the viewing public (see Figure 4.1). The temperature of the enclosure is kept between 6-11^{o}C, with a snow machine producing half a ton of snow and ice throughout the day. The penguins have no access to an outside area, and there is no 'off exhibit' area.

Figure 4.1. Penguin exhibit at Dingle Aquarium.

The penguins are hand-fed at 10:00h and 14:00h daily. Enrichment is part of the husbandry routine, and penguins receive enrichment several times per week. During the study, enrichment varied from feeding devices in the water to hanging mobiles (CDs hung from the ceiling) in the enclosure. These items have previously been determined to be successful at engaging penguins because of their natural interest in foraging and shiny objects that mimic fish scales (G. Meechan RZSS Edinburgh Zoo, pers. comm., April 18, 2015).

Data collection

In zoo-based studies increased behavioural diversity is generally considered a positive result of a treatment or condition; therefore, observed behaviours were condensed into one category 'behavioural diversity' as an overall indicator of welfare (Carlstead and Shepherdson, 2000; Clark and Melfi, 2012). However, particular attention was given to nesting behaviour and pool use, because it is essential to consider all possible effects of the zoo environment on breeding success and pool use is considered a positive behaviour for this pelagic bird (Larsson, 2012).

To quantify the behavioural response of the penguins to their environment, instantaneous scan samples of the 12 penguins were taken throughout the study period (Altmann, 1974). Scans occurred several times a week during the study. Each scan took about three minutes to complete, first the number of visitors was noted then the behaviour of each penguin was recorded (see Table 4.1 for penguin ethogram), as well as the absence (categorised as '0') or presence (categorised as '1') of enrichment. Visitor behaviour was recorded during each scan and was categorised as: 0 = all visitors compliant with aquarium rules; or 1 = at least one visitor not compliant with aquarium rules and engaging in behaviour such as banging the glass, flash photography, or climbing structures overlooking the enclosure (see Table 4.2). Noise level was not a concern in this study, as it is in many visitor effect studies (Cooke and Schillaci, 2007; Quadros et al., 2014), because the glass between the enclosure and the viewing area is soundproofed. All data were collected between 11:00-16:00, which excluded the first hour after opening and the last hour before closing. Additionally, data were not collected half an hour before and after the 14:00 feeding time. Aquarium staff participated in data collection, having been trained by the researcher. Observations were initiated by staff availability and not by the current visitor or enrichment condition, resulting in a random, independent sample of 96 observations with and without enrichment and with varying numbers of visitors (see Table 4.2). Visitor number during observations averaged 8.19 (with a SE of $\pm$1.01). Staff were never present within the enclosure when recordings occurred.

Table 4.1. Ethogram for Gentoo penguin behaviour at Dingle Aquarium.

Behaviour	Definition
Pool Behaviours	
Surface swimming	Swimming on the surface of the water
Underwater swimming	Entirely submerged and swimming under water
Preening in the Pool	Preening (see definition below) in the water
Porpoising	Jumping in an out of the water in typical penguin style
Out of Pool Behaviours	
Inactive	Individual is not in the pool and is; sitting, sleeping, standing, the absence of any other behaviour
Preening	Feather maintenance, scratching, shaking
Locomotion	Movement on land; walking, hopping, running
Affiliative	Positive social behaviour with another penguin; allo-preening, bowing
Agonistic	Negative social behaviour with another penguin; staring, beaking, attacking
Attention to enrichment	Playing with, chasing or manipulating an enrichment device
Attention to visitors	Attempting to engage in some type of interaction with a visitor such as, tapping glass with beak, following in water, actively staring at a visitor through the glass wall
Nest behaviour	Engaged in any type of behaviour involving the nest such as, moving stones or sitting on the nest
Other	An unusual occurrence, any behaviour not listed above

Table 4.2. Sample sizes for independent categorical variables

Independent variable	Category	No. of samples
Visitor behaviour*	Compliant	58
	Non-complaint	9
Presence of enrichment	No	54
	Yes	42

*n=67, because no visitors were present for 29 out of the 96 observations

Data analysis

For each observation (n=96), behavioural diversity for the penguin group was calculated using the Shannon-Weaver diversity index H (Shannon and Weaver, 1949). Behavioural diversity can increase based on the number of different behaviours performed or the number of animal performing each behaviour, therefore the minimum and maximum values will vary for each study. Here behavioural diversity ranged from 0.28 – 1.74 (See Appendix, Table A1 of this chapter for an example and Chapter 3 of this thesis for more detail).

A histogram of the data and a quantile-quantile plot revealed that the data were approximately normally distributed. First a general linear model (GLM) was conducted to test the significance of the three explanatory variables (visitor number [covariate], visitor behaviour and enrichment) on behavioural diversity with enrichment and visitor number added as an interaction term. A backwards stepwise procedure was used to remove variables with the largest p-values from the model. Validation was conducted for each model by plotting a histogram of residuals, plotting the residuals against the fitted values and checking linearity of the models. Data analysis was conducted using SPSS version 22. The accepted alpha level for these analyses was $p<0.05$.

Second, for the behaviour categories of pool behaviour and nesting behaviour, the proportion of penguins performing each of these behaviours for each observation was utilised for further analysis. A generalised linear model (GLM) with a binomial distribution was conducted for each behaviour category to test the significance of the explanatory variables (visitor number [covariate], visitor behaviour and enrichment) in addition to interactions between these explanatory variables. As over dispersion was detected in the model, the standard errors were corrected using a quasi-GLM model. A backwards stepwise procedure was used to remove variables with the largest p-values from the model and model validation was conducted by plotting the deviance residuals against the fitted values and against each explanatory variable in the model. Data analysis for this section was conducted using R version 3.2. The alpha level for statistical significance was taken to be <0.05.

Finally, because data were condensed into one category 'behavioural diversity index,' for much of the chapter, a graphical representation of all observed penguin behaviours was developed. However, because of the low occurrence of some behaviours, all pool behaviours have been collapsed to one category named ‘pool use’ and locomotion, preening, affliliative and agonistic have been collapsed to one category named ‘active,’ and the independent variable, visitor number, is represented as a categorical variable. The number of times each penguin was observed doing a certain behaviour was recorded for each category of the three independent variables tested, and the proportion of scans during which that behaviour was observed was calculated. Then, the mean proportion of scans during which each behaviour was observed was calculated for the group of penguins. These data are expressed in charts which show the prevalence of all the behaviour observed during different conditions. Tables show the mean $\pm$ SE for each behaviour.

4.3 Results

4.3.1 Behavioural diversity

Graphs of standardised residuals revealed that assumptions of normality were maintained throughout the analysis. For behavioural diversity, model selection resulted in the final model with visitor number as the only remaining explanatory variable (Appendix, Table A2 of this chapter). In this case, the variable visitor number was statistically significant ($F=5.769$; $R^2=0.058$; $p=0.018$) with higher levels of behavioural diversity being associated with higher visitor numbers (Figure 4.2).

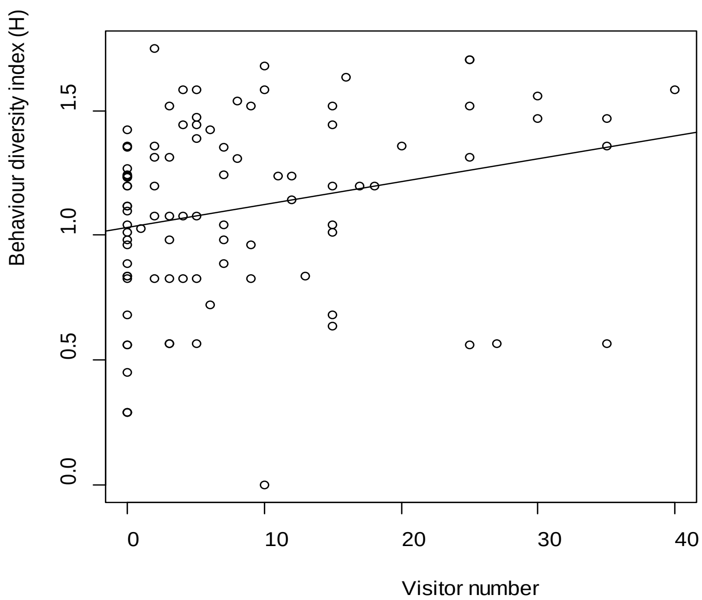


Figure 4.2. Behavioural diversity index (H) versus visitor number with regression line showing a positive relationship.

4.3.2 Pool and nest behaviour

For Nest behaviour, model selection resulted in a final model with visitor number as the only remaining explanatory variable. However, this explanatory variable was not statistically significant, therefore, none of the explanatory variables or combinations of their interactions significantly influenced penguin nest behaviour during this study (Appendix, Table A3 of this chapter). For Pool behaviour, model selection also resulted in final model with visitor number as the only remaining explanatory variable. In this case, the variable visitor number was statistically significant ($p=0.020$) with higher levels of pool behaviour being associated with higher visitor numbers (Appendix, Table A3 this chapter; Figure 4.3).

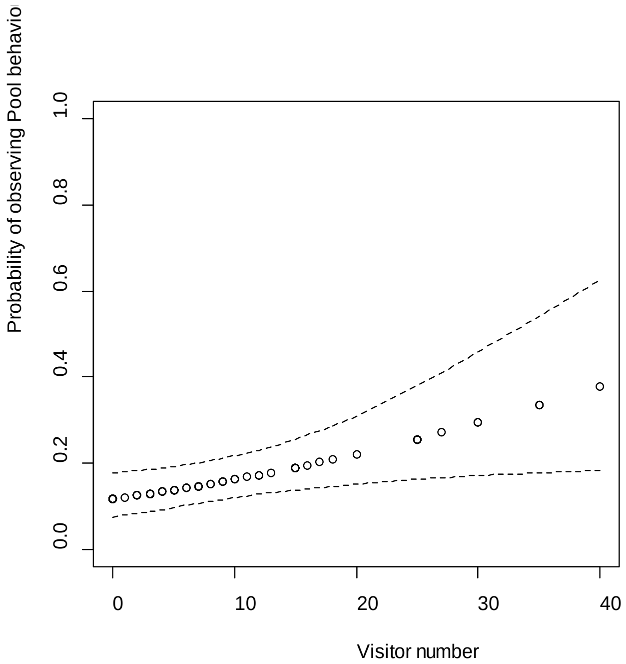


Figure 4.3. Fitted values and 95% confidence bands for the optimal GLM model for Pool behaviour for the group of penguins at Dingle aquarium.

4.3.3 Prevalence of specific behaviours during different conditions

For each condition of each variable tested nesting behaviour was the most prevalent behaviour observed with the pool use, active and inactive the three most common behaviours observed after nesting (Figure 4.4-4.6 and Tables 4.3-4.5).

Number of visitors present

The prevalence of behaviours between no visitors present and 1-10 visitors present is similar (Figures 4.4A and B). Although with 1-10 visitors present, penguins were slightly less inactive than when no visitors were present (0.17 vs 0.26) and more likely to use the pool (0.15 vs 0.09) (Table 4.3). Additionally, the birds were able to spend a small proportion of time paying attention to visitors (0.01) (Table 4.3). The penguins engaged in more types of behaviours, especially active behaviours like pool use (0.25), active (0.20) and attention to visitors (0.04) when the most visitors (11-40) were present; however, nesting behaviour (0.36) decreased during this condition (Figure 4.4C and Table 4.3).

Table 4.3. The mean proportion of penguins engaged in each behaviour ± SE.

	No visitors	**1 – 10 visitors**	**11 – 40 visitors**
Pool use	0.09±0.012	0.15±0.027	0.25±0.031
Inactive	0.26±0.030	0.17±0.026	0.12±0.016
Active	0.17±0.018	0.18±0.019	0.20±0.022
Enrichment	0.02±0.008	0.02±0.008	0.01±0.011
Visitor Attention	0.00±0.000	0.01±0.004	0.04±0.014
Nest	0.43±0.054	0.46±0.057	0.36±0.044
Other	0.03±0.011	0.02±0.006	0.01±0.005

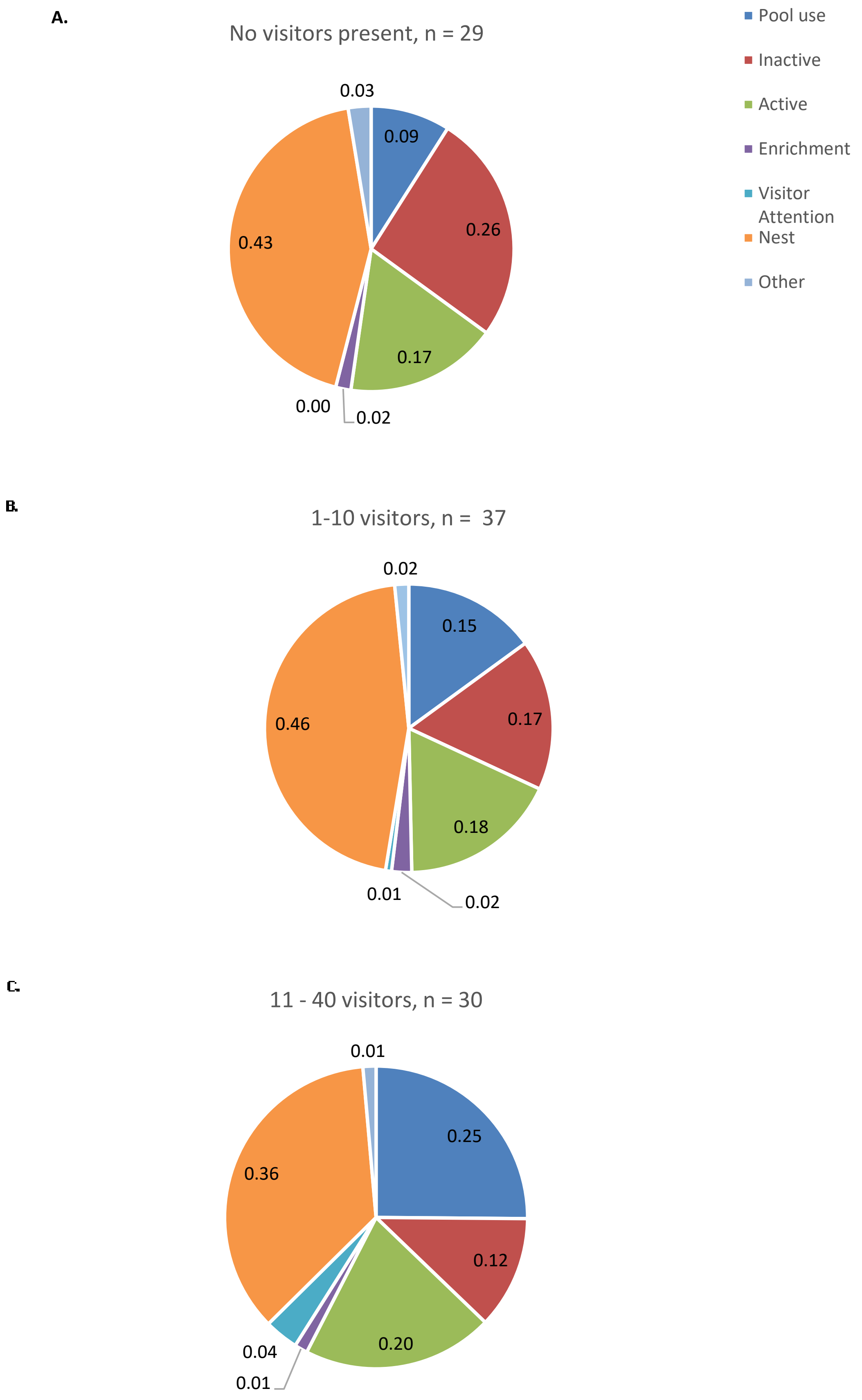


Figure 4.4. The mean proportion of penguins during the observations that were engaged in the behaviours listed when A) no visitors were present B) 1-10 visitors were present and C) 11-40 visitors were present.

Visitor behaviour

Figure 4.5A and B shows that the prevalence of the behaviour between times when visitors were and were not compliant with aquarium rules is generally similar. However, when visitors were compliant with the aquarium rules, penguins engaged slightly more with enrichment (0.01) and paid less attention to visitors than when they were not compliant with the rules (0.02 vs 0.06) (Table 4.4). Both active (0.15 vs 0.20) and inactive decreased slightly (0.09 vs 0.16) when visitors did not comply with the rules compared to when they were compliant with the rules. Interestingly, the category other increased (0.08 vs 0.01) when visitors were not compliant with rules, which represents the highest observation of this category (Table 4.4).

Table 4.4. The mean proportion of penguins engaged in each behaviour ± SE.

	Visitors compliant with rules	Visitors not compliant with rules
Pool use	0.19±0.023	0.22±0.049
Inactive	0.16±0.020	0.09±0.019
Active	0.20±0.018	0.15±0.034
Enrichment	0.01±0.005	0.00±0.000
Visitor Attention	0.02±0.009	0.06±0.021
Nest	0.42±0.047	0.39±0.046
Other	0.01±0.005	0.08±0.031

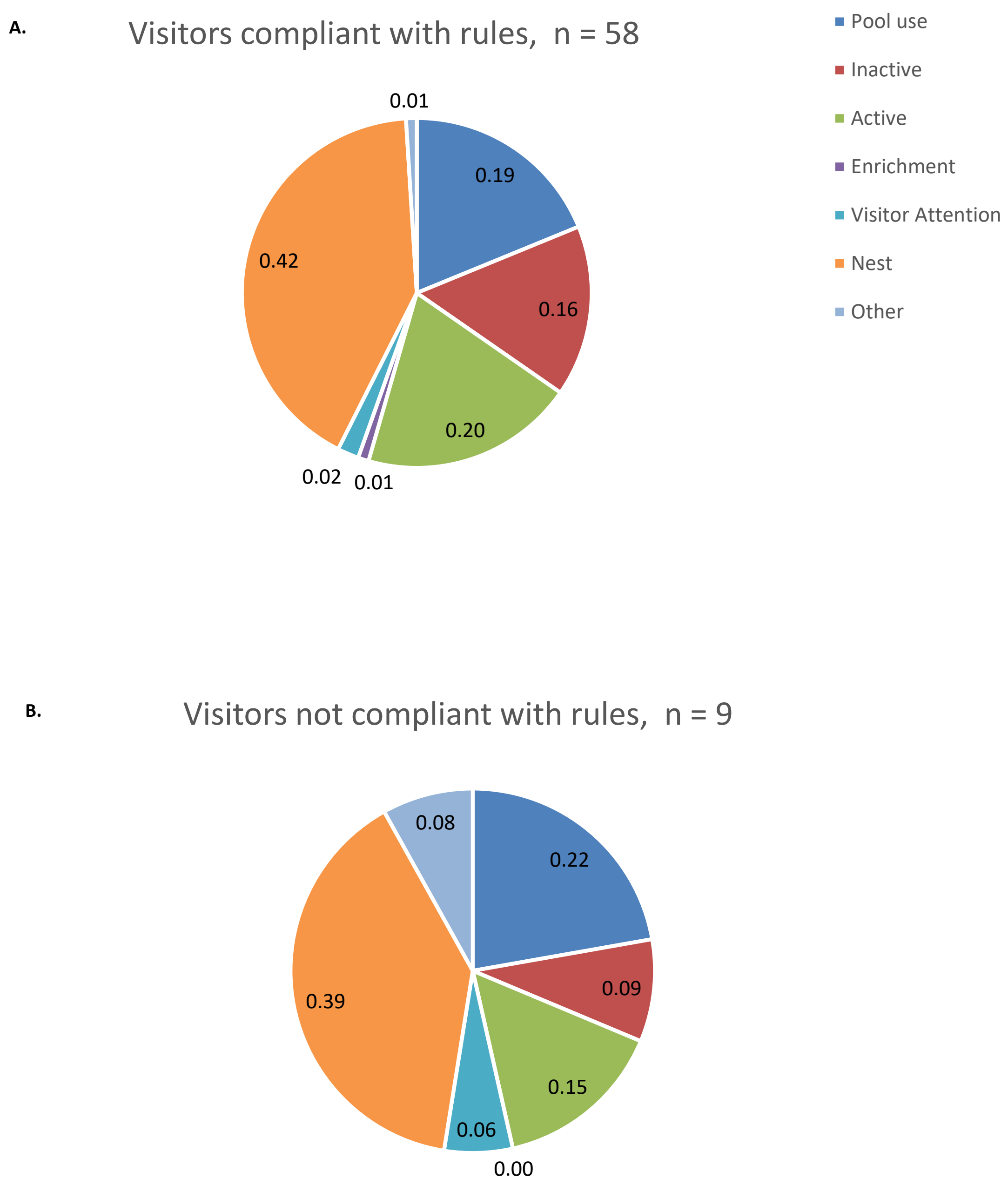


Figure 4.5. The mean proportion of penguins during the observations that were engaged in the behaviours listed when A) visitors were compliant with rules and B) not compliant with rules.

.

Enrichment

Once again, the behaviours displayed by the penguins with and without enrichment present are similar (Figure 4.6A and B). However, when enrichment was present, this enabled penguins to engage with it (0.03). Additionally, attention to visitors increased slightly to (0.03) when enrichment was present compared to (0.01) when it was not (Table 4.5).

Table 4.5. The mean proportion of penguins engaged in each behaviour ± SE.

	No Enrichment	Enrichment
Pool use	0.18±0.020	0.16±0.022
Inactive	0.18±0.017	0.19±0.024
Active	0.18±0.017	0.19±0.022
Enrichment	0.00±0.000	0.03±0.012
Visitor Attention	0.01±0.006	0.03±0.007
Nest	0.43±0.045	0.40±0.052
Other	0.03±0.007	0.01±0.005

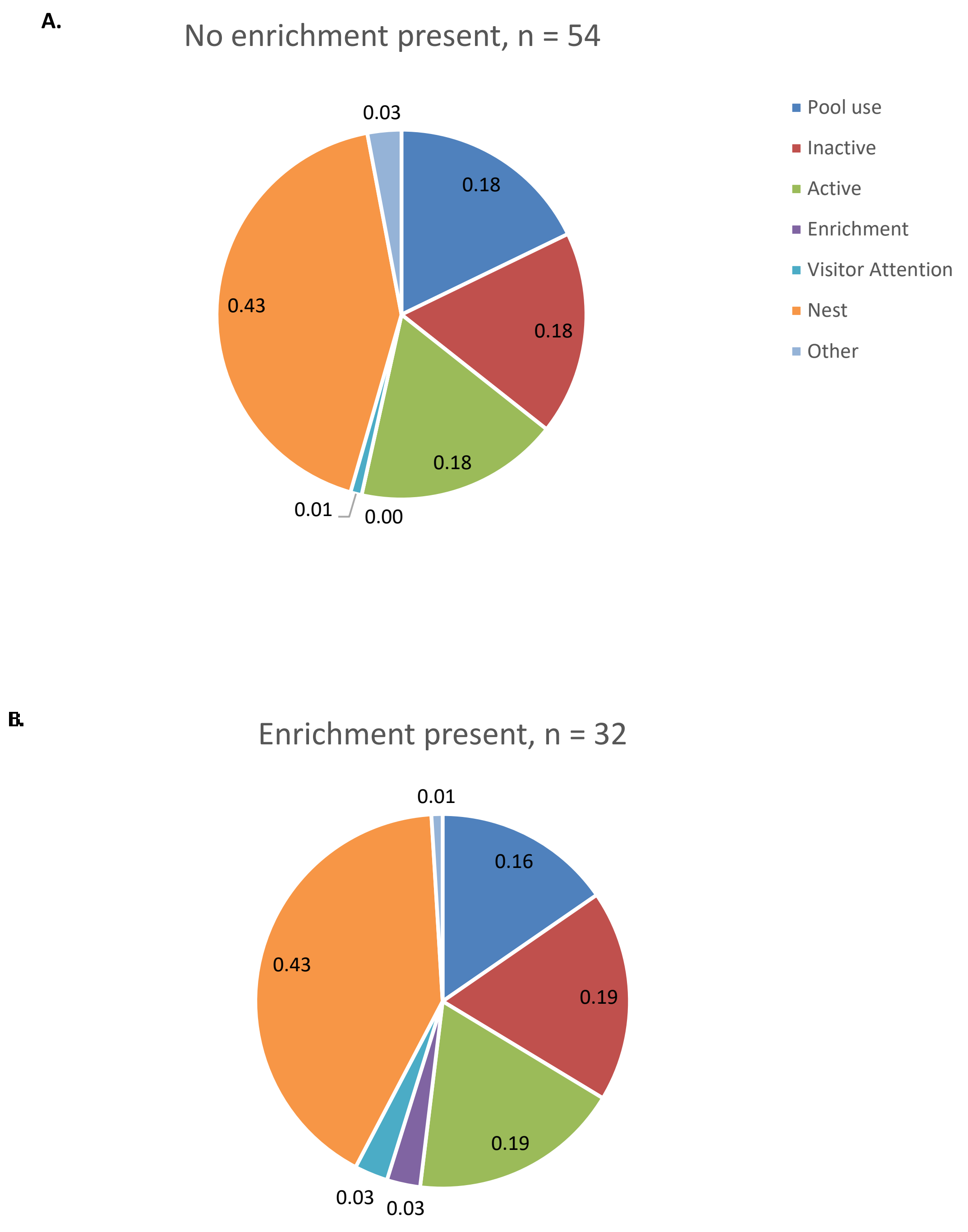


Figure 4.6. The mean proportion of penguins during the observations that were engaged in the behaviours listed when A) no enrichment was present and B) when enrichment was present.

4.4 Discussion

In contrast to some wild populations of penguins, the Gentoo penguin group at Dingle Aquarium showed a behavioural response to the presence of visitors, indicated by a positive association between visitor number and behavioural diversity. Pool use was associated with higher numbers of visitors. This may indicate that penguins are not negatively affected by visitors, but they may respond positively to visitors by becoming more active, thus supporting the hypothesis that in some circumstances visitors may be stimulating to captive animals (Morris, 1964; Hosey, 2000). In the current study, pool use is considered a positive outcome since penguins are pelagic birds that naturally spend large amounts of time foraging at sea and this contributes to the overall level of behavioural diversity (Larsson, 2012). Condon et al. (2003), also report that Humboldt penguins swam and specifically dove more when visitors interacted with penguins through an underwater viewing window. Of course, in visitor-animal interaction studies directionality must be considered (Margulis et al., 2003; Hosey, 2008) since it is known that visitors are attracted to active animals (Bitgood el al., 1988; Margulis, et al., 2003). The current study supports that hypothesis; when penguins were swimming in the pool, a larger group of visitors was present. However, without further investigation, it is difficult to disentangle directionality in this situation; this could be an area for further research.

There was little indication that the penguins changed their behaviour towards their nests during any of the conditions of the study. A closer examination of the individual penguin behaviours showed a slight decline in nest behaviour when the highest numbers of visitors were present, though this was not statistically significant. This is in contrast to what has been reported by Wilson et al. (1991) that in the wild Adélie penguins may abandon their nests when tourists approach. It is likely that the captive-born penguins in this study have habituated to the zoo environment so that their nesting behaviour is not affected, which is similar to what Yorio and Boersma (1992), Walker et al., (2006) and Villanueva et al., (2014) reported in wild populations of Magellanic penguins exposed to tourists during the breeding season. Yet, it should be noted that at the time of the study the penguins at Dingle Aquarium had only produced one live chick. The reason for this is unknown (staff at the aquarium suggest it may be due to the penguins' relatively recent arrival at the aquarium and the necessary adjustment time to the change in photoperiod, L. Overy, personal observation, January 15, 2016), but given the results of this study, visitor disturbance seems an unlikely cause;

however, until further investigation is carried out all possibilities should be considered. Blay and Côté (2001) recommend that penguin population and pool size, as well as enclosure substrate and nesting material be considered when assessing breeding success. Additionally, future work should consider if behavioural diversity varies outside of the breeding season, as nesting and breeding may affect behavioural responses.

There was a low rate of visitor non-compliance with aquarium rules; therefore, the sample size of visitors behaving badly was low. Regardless, no difference in behavioural diversity was detected when visitors did or did not comply with the aquarium rules. Examination of individual behaviours showed slight differences between the two conditions. Namely, penguins were more likely to pay attention to visitors if they were not compliant with the rules. For example, a visitor banging the glass may have attracted the penguins' attention. Also, there was an increase in the category 'other' when visitors were not compliant with the rules, but unfortunately the actual behaviour was not recorded so this is not possible to interpret. It may be premature to state that penguins are not affected by banging, climbing and flash photography. An important consideration of the present study is that, as mentioned above, the glass separating the visitors and penguins at Dingle Aquarium is virtually soundproof. Some previous studies have shown that it is noise, in particular, that may disturb captive animals (Birke, 2002; Cooke and Schillaci, 2007; Quadros et al., 2014). Additionally, Nimon et al., (1996) found that wild penguins may be adversely affected by specific negative behaviours of visiting humans and not just their presence; they further report that 'the presence of a well-behaved visitor' may barely affect nesting penguins (Nimon et al., 1995, p. 415). Furthermore, Carney and Sydeman, (1999) suggest that wild penguins show little behavioural response to humans, but may react with a physiological response such as increased heart rate, which may be too subtle to be detected by changes in their behaviour. However, Ozella et al., (2017) did investigate adrenocortical activity in captive African penguins (*Spheniscus demersus*) by measuring faecal glucocorticoid metabolites (FGM) and found no association between visitor number and adrenocortical activity. Physiological monitoring of captive penguins was out of the scope of the current study, but simultaneous monitoring of behavioural and physiological response could be an area for further investigation. It is essential to consider that if penguins were continuously exposed to higher degrees of negative visitor behaviour and noise the results may be significantly different, as previous studies have shown that captive birds may have a threshold of tolerance for visitors (Nimon and Dalziel, 1992; Collins and Marples, 2015).

Similar to the findings of Clarke (2003), the penguins in this study showed no change in behavioural diversity levels when enrichment was absent or present. Closer examination of individual behaviours only showed that penguins were slightly more likely to engage with enrichment if it was present. This may have been due to the type of enrichment used. Distinguishing between pool-based and non-pool-based enrichment devices may have clarified penguins' preferred type of enrichment. It would be ideal to use a specific type of enrichment consistently; however, this was not possible in the present study due to husbandry routines. Future work could focus on the penguins' response to different types of enrichment, in a randomised design, to isolate any effects of different enrichment devices (Quirke and O'Riordan, 2011).

Finally, we consider the educational potential of the Gentoo penguins at Dingle Aquarium. The penguins are amongst the visitors' favourite animals at Dingle Aquarium (M. O'Shea, personal communication, November 6, 2014), and recently, penguins in general have received much attention in the media, which may also contribute to visitor interest (Wagoner and Jensen, 2010). Although, Moss and Esson (2010) found that birds were amongst the least exciting animals to zoo visitors, they suggest that in the absence of mammals, as at Dingle Aquarium at the time of the study, bird species may become more interesting to visitors. The results of this study appear to support previous research that visitors are attracted to more active animals (Bitgood et al., 1988; Moss and Esson, 2010). However, it is not known if the visitors actually learned more by observing the birds when they were active, which could be an area of further research (see Chapters 5 and 7). Yet, it appears that visitors are attracted to the swimming penguins and the penguins do not show an adverse behavioural reaction to the visitors, indicating that their educational potential is high.

Zoos must balance their goals of conservation, education, entertainment and welfare; yet, these goals can appear contradictory. By attracting large crowds of visitors, who offer financial support for conservation and participate in education programmes, there is also the possibility of diminished animal welfare (Fernandez et al., 2009; Hosey, 2013). However, here, there is evidence that large numbers of visitors at the penguin enclosure did not appear to interfere with the animals' welfare and may be enriching. This finding supports the idea that zoos may be able to use husbandry routines to their advantage, to encourage animals to be more active (taking careful consideration of animal welfare) when visitors are present, perhaps through the use of enrichment, which would benefit both captive animals and visitors alike (Margulis et al., 2003; Moss and Esson, 2010). Although, in the current study, penguin behavioural diversity level did not change when enrichment was present, perhaps a different type of enrichment, or an interactive device that visitors could use may benefit both visitors' learning and penguins' welfare and should be investigated further. It is suggested, based on this current research that penguins (especially at aquariums) may prove to be the ideal 'educational' animal.

4.5 Conclusions

1. As visitor numbers increased, penguin behavioural diversity levels increased. However, behavioural diversity was not affected by enrichment or by visitors not complying with aquarium rules, but the sample size is small and further research would be beneficial.
2. Pool use was affected by visitors. As visitor numbers increased, the number of penguins using the pool increased. It is not possible at this point to determine the directionality of this association.
3. Nesting behaviour was not affected by any of the variables tested in the study.
4. Penguins at Dingle aquarium have high educational potential.

4.6 References

Altmann, J. (1974). Observational study of behavior: sampling methods. *Behaviour*, 49(3), 227-266.

Birke, L. (2002). Effects of browse, human visitors and noise on the behaviour of captive orang-utans. *Animal Welfare*, 11(2), 189-202.

Bitgood, S., Paterson, D. & Benefield, A. (1988). Exhibit design and visitor behaviour: empirical relationships. *Environmental Behavior*, 20, 474-491.

Blay, N. & Côté, I. M. (2001). Optimal conditions for breeding of captive Humboldt penguins (*Spheniscus humboldti*): a survey of British zoos. *Zoo Biology*, 20(6), 545-555.

Burger, J. & Gochfeld, M. (2007). Responses of Emperor Penguins (*Aptenodytes forsteri*) to encounters with ecotourists while commuting to and from their breeding colony. *Polar Biology*, 30(10), 1303-1313.

Carder, G. & Semple, S. (2008). Visitor effects on anxiety in two captive groups of western lowland gorillas. *Applied Animal Behaviour Science*, 115, 211-220.

Carlstead, K. & Shepherdson, D. (2000). Alleviating stress in zoo animals with environmental enrichment. In: G. P. Moberg & J. A. Mench (Eds.), *The biology of animal stress: Basic principles and implications for animal welfare*. CABI. p. 337-354.

Carney, K. M. & Sydeman, W. J. (1999). A review of human disturbance effects on nesting colonial waterbirds. *Waterbirds*, 22, 68-79.

Clarke, A. G. (2003). Factors affecting pool use by captive Humboldt penguins (*Spheniscus humboldti*). In *Proceedings of the 5th Annual Symposium on Zoo Research, Marwell Zoological Park, Winchester, UK, 7-8th July 2003.* (pp. 190-204). Federation of Zoological Gardens of Great Britain and Ireland.

Clark, F. E., Fitzpatrick, M., Hartley, A., King, A. J., Lee, T., Routh, A. & George, K. (2012). Relationship between behavior, adrenal activity, and environment in zoo-housed western lowland gorillas (*Gorilla gorilla*). *Zoo Biology*, 31(3), 306-321.

Clark, F. E. & Melfi, V. A. (2012). Environmental enrichment for a mixed-species nocturnal mammal exhibit. *Zoo Biology*, 31(4), 397-413.

Claxton, A. M. (2011). The potential of the human–animal relationship as an environmental enrichment for the welfare of zoo-housed animals. *Applied Animal Behaviour Science*, *133*(1), 1-10.

Cobley, N. D. & Shears, J. R. (1999). Breeding performance of Gentoo penguins (*Pygoscelis papua*) at a colony exposed to high levels of human disturbance. *Polar Biology*, 21(6), 355-360.

Collins, C. K. & Marples, N. M. (2015). Zoo Playgrounds: A Source of Enrichment or Stress for a Group of Nearby Cockatoos? A Case Study. *Journal of Applied Animal Welfare Science*, 18 (4), 375-387.

Condon, E., Wehnelt, S. & Turner, Z. (2003). The effect of visitors on the behaviour of Humboldt's penguins at Chester Zoo. *Federation Research Newsletter*, 4(2), 3.

Cooke, C. M. & Schillaci, M.A. (2007). Behavioural responses to the zoo environment by white-handed gibbons. *Applied Animal Behaviour Science,* 106, 125-133.

Culik, B. & Wilson, R. (1991). Penguins crowded out? *Nature*, 351(6325), 340-340.

Culik, B. & Wilson, R. (1995). Penguins disturbed by tourists. *Nature*, 376, 301-302.

Ellenberg, U., Setiawan, A. N., Cree, A., Houston, D. M. & Seddon, P. J. (2007). Elevated hormonal stress response and reduced reproductive output in Yellow-eyed penguins exposed to unregulated tourism. *General and Comparative Endocrinology*, 152(1), 54-63.

Fernandez, E. J., Tamborski, M. A., Pickens, S. R. & Timberlake, W. (2009). Animal–visitor interactions in the modern zoo: Conflicts and interventions. *Applied Animal Behaviour Science,* 120(1), 1-8.

Hosey, G. (2000). Zoo animals and their human audiences: what is the visitor effect? *Animal Welfare*, 9, 343-357.

Hosey, G. (2008). A preliminary model of human–animal relationships in the zoo. *Applied Animal Behaviour Science*, 109(2), 105-127.

Hosey, G. (2013). Hediger revisited: how do zoo animals see us? *Journal of Applied Animal Welfare Science,* 16(4), 338-359.

The IUCN Red List of Threatened Species. Version 2017-1. <http://www. iucnredlist.org>. Date last accessed June 8, 2018.

Jensen, E. (2014). Evaluating children's conservation biology learning at the zoo. *Conservation Biology*, 28(4), 1004-1011.

Larsson, A. (2012). Development and evaluation of environmental enrichment for captive Humboldt penguins. Swedish University of Agricultural Sciences, Department of Animal, Environment and Health Ethology and Animal Welfare programme. Student Report 443.

Margulis, S. W., Hoyos, C. & Anderson, M. (2003). Effect of felid activity on zoo visitor interest. *Zoo Biology*, 22(6), 587-599.

McClung, M. R., Seddon, P. J., Massaro, M. & Setiawan, A. N. (2004). Nature-based tourism impacts on yellow-eyed penguins *Megadyptes antipodes*: does unregulated visitor access affect fledging weight and juvenile survival? *Biological Conservation*, 119(2), 279-285.

Mellen, J. & MacPhee, M. S. (2001). Philosophy of environmental enrichment: past, present, and future. *Zoo Biology*, 20(3), 211-226.

Morris, D. (1964). The response of animals to a restricted environment. In *Symposia of the Zoological Society, London,*13, 99-118.

Moss, A. & Esson, M. (2010). Visitor interest in zoo animals and the implications for collection planning and zoo education programmes. *Zoo Biology*, 29(6), 715-731.

Nimon, A. J. & Dalziel, F. R. (1992). Cross-species interaction and communication: a study method applied to captive siamang (*Hylobates syndactylus*) and long-billed corella (*Cacatua tenuirostris*) contacts with humans. *Applied Animal Behaviour Science*, 33(2), 261-272.

Nimon, A. J., Schroter, R. C. & Stonehouse, B. (1995). Heart rate of disturbed penguins. *Nature*, 374(6521), 415.

Nimon, A. J., Schroter, R. C. & Oxenham, R. K. (1996). Artificial eggs: measuring heart rate and effects of disturbance in nesting penguins. *Physiology and Behavior*, 60(3), 1019-1022.

Ozella, L., Favaro, L., Carnovale, I. & Pessani, D. (2015). Pond Use by Captive African Penguins (*Spheniscus demersus*) in an Immersive Exhibit Adjacent to Human Bathers. *Journal of Applied Animal Welfare Science*, 18(3), 303-309.

Ozella, L., Anfossi, L., Di Nardo, F. & Pessani, D. (2017). Effect of weather conditions and presence of visitors on adrenocortical activity in captive African penguins (*Spheniscus demersus*). *General and Comparative Endocrinology, 242*, 49-58.

Quadros, S., Goulart, V. D., Passos, L., Vecci, M. A. & Young, R. J. (2014). Zoo visitor effect on mammal behaviour: Does noise matter? *Applied Animal Behaviour Science*, 156, 78-84.

Quirke, T. & O'Riordan, R. M. (2011). The effect of a randomised enrichment treatment schedule on the behaviour of cheetahs (*Acinonyx jubatus*). *Applied Animal Behaviour Science*, 135(1), 103-109.

Seddon, P. J. & Ellenberg, U. (2008). Effects of human disturbance on penguins: the need for site and species specific visitor management guidelines. *Marine wildlife and tourism management: Insights from the natural and social sciences*, 163-181.

Shannon, C. E. & Weaver, W. (1949). *The Mathematical Theory of Information.* University of Illinois Press, Urbana, IL.

Species 360. https://www.species360.org/. Last date accessed August 22, 2018.

Steven, R., Pickering, C. & Castley, J. G. (2011). A review of the impacts of nature-based recreation on birds. *Journal of Environmental Management*, 92(10), 2287-2294.

Stoinski, T. S., Jaicks, H. F. & Drayton, L. A. (2012). Visitor effects on the behavior of captive western lowland gorillas: the importance of individual differences in examining welfare. *Zoo Biology*, 31(5), 586-599.

Swaisgood, R. R. & Shepherdson, D. J. (2005). Scientific approaches to enrichment and stereotypies in zoo animals: what's been done and where should we go next? *Zoo Biology*, 24(6), 499-518.

Villanueva, C., Walker, B. G. & Bertellotti, M. (2012). A matter of history: effects of tourism on physiology, behaviour and breeding parameters in Magellanic Penguins (*Spheniscus magellanicus*) at two colonies in Argentina. *Journal of Ornithology*, 153(1), 219-228.

Villanueva, C., Walker, B. G. & Bertellotti, M. (2014). Seasonal variation in the physiological and behavioral responses to tourist visitation in Magellanic penguins. *The Journal of Wildlife Management*, 78(8), 1466-1476.

Wagoner, B. & Jensen, E. (2010). Science learning at the zoo: Evaluating children's developing understanding of animals and their habitats. *Psychology and Society*, 3(1), 65-76.

Walker, B. G., Boersma, P. D. & Wingfield, J. C. (2006). Habituation of adult Magellanic penguins to human visitation as expressed through behavior and corticosterone secretion. *Conservation Biology*, 20(1), 146-154.

Wilson, R. P., Culik, B., Danfeld, R. & Adelung, D. (1991). People in Antarctica - how much do Adélie Penguins (*Pygoscelis adeliae)* care? *Polar Biology*, 11(6), 363-370.

Yorio, P. & Boersma, P. D. (1992). The effects of human disturbance on Magellanic penguin (*Spheniscus magellanicus*) behaviour and breeding success. *Bird Conservation International*, 2(03), 161-173.

Chapter 4: Appendix

Table A1. A random cross sample of observations to illustrate how frequency of behaviour, and the number of penguins performing the behaviours relates to behavioural diversity, with varying levels of behavioural diversity (H) indicated in the last column.

	Behaviours (number of times observed for different observations), 13 behaviours in total; 12 penguins													
	Surface	Under	H_2O preen	Jump	Inactive	Preen	Loco	Affil	Agon	Vis Attn	Enrich	Nest	Other	Behaviour diversity calculation (H)
Observation 1	0	0	0	0	11	0	1	0	0	0	0	0	0	**0.286836**
Observation 2	0	1	0	0	0	0	0	0	0	1	0	10	0	**0.566086**
Observation 3	0	0	0	0	4	0	0	0	4	0	0	4	0	**1.098612**
Observation 4	2	2	0	0	2	0	0	1	2	0	0	3	0	**1.748155**

Table A2. Models applied for Humboldt penguins' behavioural diversity level using GLMs.

Model	Independent variables	Description	Variables removed from the model, p-value
M1	Visitor number + Enrichment + Visitor behaviour + Visitor number*Enrichment	All variables	Interaction term, p = 0.357
M2	Visitor number + Enrichment +	No interaction	Visitor behaviour, p = 0.641
M3	Visitor behaviour Visitor number + Enrichment	No interaction or visitor behaviour	Enrichment, p = 0.131
	Variable remaining in the model	**Description**	**p-value**
M4	Visitor number	Final Model	p = 0.018

Table A3. Remaining explanatory variable after backwards selection, estimate, standard error, p-value residual deviance and degrees of freedom information for binomial GLM models.

Behaviour	Variable remaining in model	Estimate	Standard Error	p-value	Residual deviance, df
Nest	Visitor number	-0.01514	0.009523	0.1155	257.76, 94
Pool	Visitor number	0.03843	0.01625	0.0201	403.32, 94

Section B

Children's education

Chapter 5

A survey-based evaluation of the impact of an educational intervention on children's knowledge, attitude and behaviour in the zoo setting.

Abstract

School children comprise a large number of the visitors to zoos and aquariums every year. Yet, even though zoos have been criticised for failing to demonstrate a positive effect of their education programmes on visitors' learning, few studies have explored the impact of a zoo visit on children's learning. Furthermore, zoos should inspire their visitors towards positive conservation action and behaviour change not just cognitive knowledge gain. This study investigates students' (9-12 years) knowledge about certain species, attitude towards zoo animals and learning, and behaviour towards zoo animals using data gathered from 501 questionnaires. The study uses a repeated measures design to assess changes in learning as a result of a visit to Fota Wildlife Park or Dingle Aquarium. Additionally, the treatment group participated in a purposefully developed educational intervention intended to enhance learning. Results from the surveys show that learning does occur after a zoo or aquarium visit. Increases in knowledge and behaviour scores were greater in students visiting Fota Wildlife Park and those who participated in the educational intervention. Attitude was less likely to be affected, but increases in positive attitude were recorded in girls and those visiting Fota Wildlife Park. The results show that a zoo visit has educational benefits for children, but those who participate in the hands-on educational intervention were broadly more likely to have greater increases in learning.

5.1 Introduction

Each year millions of children visit zoos, where they encounter a wide array of exotic animals and educational messages (Jensen, 2014). Zoos report that their highest priority is educating visitors, particularly school children (Roe et al., 2014). Therefore, zoos should be ideally positioned to play an important role in science education, specifically biological science and conservation (Jensen, 2014). Yet, it has proven difficult for zoos to demonstrate the impact of their education progammes on visitors' learning (Moss and Esson, 2013). Furthermore, Jensen (2014) summarises that previous educational research on zoos, has frequently only alluded to the actual educational impact of a zoo visit and focused instead on other variables such as visitor density and stay time at exhibits, as a means of making a connection to visitor learning. Additionally, research that has investigated the impact of zoological education has been criticised for methodological errors (Marino et al., 2010) or only using post-visit group data, which makes identifying patterns in individuals difficult (Jensen, 2014). Rarely have previous studies considered the impact of a zoo visit on children's learning.

Yet, despite the above concerns, research on the impact of zoo's education programmes has occurred. Falk et al. (2007) evaluated the impact of visiting a zoo or aquarium on adult visitors' learning and found a positive association between the visit and conservation attitudes. However, the data were gathered with an exit survey (retrospective-pre-survey) only, which has been criticised for overestimating programme effect (Marino et al., 2010). Still, the authors report that 54% of participants in the study reported a heightened awareness of conservation issues as a result of the visit, 61% said that their visit supported their existing attitude toward conservation and 42% cited the importance of zoos and aquariums in conservation education (Falk et al., 2007). However, the authors also reported that there was no overall change in knowledge after the visit, which they attributed to visitors having higher than expected knowledge of ecological concepts (Falk et al., 2007).

In contrast, an early study at the National Aquarium in Baltimore (NAIB), which considered adults knowledge, attitude and behaviour, in a pre-post interview format, found that the visit positively influenced visitors' knowledge, but did not lead to a positive change in conservation actions (Adelman et al., 2000). However, the authors emphasised that learning at a zoo or aquarium may take time to assimilate and may not become apparent till weeks or months later. Indeed, the results of their follow-up study, six to eight weeks later, indicated that changes in knowledge persisted or even grew, but commitment to conservation related actions returned to original levels prior to the visit. The authors acknowledged that the visitors to the NAIB were a self-selected group (they chose to visit the aquarium) and had strong positive attitudes towards conservation issues upon entering the aquarium. Still, Adelman et al. (2000) concluded that generally the visit led to a more profound understanding of conservation issues. A more recent large-scale global study which evaluated zoos' ability to raise visitors' awareness of biodiversity with repeated measures pre- and post-surveys, also found a significant positive association between the visit and visitors' understanding of biodiversity and knowledge of actions to protect biodiversity (Moss et al., 2015).

These results are in contrast to Balmford et al. (2007) who found almost no evidence of knowledge gain at seven UK zoos in adults' conservation learning after a visit to the zoo. However, this study compared the conservation knowledge of visitors arriving at the zoo with a separate group of visitors exiting the zoo, which may have made it difficult to detect knowledge gain at an individual level as a result of a zoo visit.

To date, the only comprehensive large-scale study involving children concerned 7-15-year olds visiting the Zoological Society of London (London Zoo) (Jensen, 2011; 2014). It was discovered that 53% of students who participated in the formal education programme showed positive development in at least one area of concern, such as empathy for endangered species (Jensen, 2011). The author reported significant knowledge gain in conservation related learning from pre- to post-visit in individuals, particularly in the area of understanding animal habitats. Educator-led visits showed the highest positive outcome (41%) and the lowest negative outcome (11%) compared to unguided visits (Jensen, 2014). Jensen (2014) emphasised the importance of the educational leader by relating it to Vygotsky's social development theory with the zoo-educator as the 'more knowledgeable other.' However, while methodologically rigorous, Jensen (2011) did not explore children’s behaviour or intended actions while visiting the zoo, rather the study focused on conservation related knowledge gain and attitude toward conservation.

Several smaller studies have assessed the impact of a specific intervention on learning in the zoo. Randler et al. (2007) considered the impact of educational materials provisioned at workstations in the zoo on cognitive (knowledge) and affective (emotional) benefits in students (11-12 years) while visiting a zoo in Germany. Similar to the current study, the students were classified as control or treatment groups. The treatment groups visited a hands-on workstation on birds, while the control group visited one on reptiles. The visit did not include a structured tour of the zoo as is typical with school visits in Ireland, but rather relied on self-determined learning, where students work independently and teachers support rather than instruct (Randler et al., 2007). Both control and treatment groups had similar pre-visit test scores on bird adaptations, but one week after the visit the treatment group scored significantly better than the control group. After the follow-up visit, eight to nine week later, the treatment group scored significantly higher than the control group again but did slightly worse than their scores one week after the visit (Randler et al., 2007). The authors also reported that girls in the treatment groups scored higher than boys in the follow-up test, but not immediately following the visit (Randler et al., 2007). Conversely, in regard to emotional benefits, the children in the control group scored better. The authors attributed this to children’s heightened interest in the reptiles over birds, though this is in contrast to what previous research has found on visitor preference for certain taxa (Moss and Esson, 2010). Visscher et al. (2009) also discovered that students who observed an interpretive presentation about black rhinoceros (*Diceros bicornis*) scored higher on a knowledge quiz than groups that did not see the interpretive presentation.

Lindemann-Matthies and Kamer (2006) considered the effect of touch tables on adult visitors’ learning about birds in a Swiss zoo. The touch tables included specific information on bearded vultures (*Gypaetus barbatus*), a volunteer to answer questions and the opportunity to touch different artefacts. Importantly, the tables were located next to the vultures, so that their behaviour could also be observed. The current study has broadly followed the research design of Lindemann-Matthies and Kamer (2006) in which both control and treatment groups, who experienced an additional educational experience, were tested pre- and post-visit. Compared to looking at signage alone, the authors discovered that visitors who used the touch tables knew more about bearded vultures immediately and two months after their visit (Lindemann-Matthies and Kamer, 2006). Unfortunately, they did not consider the impact of their educational intervention on visitors' behaviour or on children. However, the authors reported that overall the interactive educational approach was successful with adult visitors (Lindemann-Matthies and Kamer, 2006).

Yet, zoos are expected to do more than provide their visitors with facts and knowledge, they are expected to influence visitors' attitudes towards conservation and ultimately encourage pro-environmental behaviour and actions (Hungerford and Volk, 1990; Ogden and Heimlich, 2009; Luebke et al., 2016). Given the lack of information surrounding the impact of informal science education at zoos and aquariums on children's learning, particularly in the areas of attitude and behaviour, the current study developed a survey which aimed to quantify the effects of a zoo/aquarium visit in Ireland. Questions on the knowledge section of the survey were specifically developed to assess children's understanding of the two animal species (ring-tailed lemurs and penguins) included in this research. Some participating groups experienced a purposefully developed, hands-on educational intervention, which supplemented standard curriculum. The possibility of a negative impact or a decrease in learning after a visit to the zoo or aquarium was also considered (Jensen, 2014). The specific aims of the current research were to investigate:

1) The impact of a zoo or aquarium visit on children's knowledge, attitude and behaviour.

2) The impact of a purposefully developed educational intervention on children's knowledge, attitude and behaviour.

3) Other variables which may affect learning outcomes in the zoo or aquarium.

5.2 Methodology

Reliability and validity

The research follows a classic repeated measures experimental design (Oppenheim, 1992) (Figure 5.1), which allows for the detection of 'patterns of conceptual development' or changes in both positive and negative thinking to emerge as a result of an educational experience at an individual level (Jensen, 2011; p.6; Moss et al., 2015). Given the criticisms which have recently been directed at zoological education studies because of implied methodological flaws (Jensen, 2014; Marino et al., 2010), the current study followed a rigorous design to produce valid and reliable results (Wellington and Szczerbinski, 2007; Jensen, 2014).

For example, throughout the research several checks on reliability occurred (e.g. inter-coder reliability and Cronbach's alpha to test for internal consistency). Since validity can be more difficult to demonstrate (Oppenheim, 1992; Cohen et al., 2007), to ensure validity, a controlled experimental approach was employed, methodology was meticulously selected, the survey instrument was examined by experts in the field and data analysis was rigorous (Cohen et al., 2007; Wellington and Szczerbinski, 2007). Furthermore, since triangulation is vital to internal validity (Mulcahy-O'Mahony, 2013), investigator triangulation occurred throughout the research. Methodological triangulation included a mixed-method approach to data collection (Denzin, 1970; Bexell, 2006; Wellington and Szczerbinski, 2007). Jensen (2014) reported that informal learning studies should not rely solely on 'self-report' data collected from surveys. Hence, the current study gained information on children's learning in the zoo from additional methods including behavioural observation and conversational content analysis, the results of which are reported elsewhere in the thesis (Chapters 7 and 8). However, there are certain variables that the study could not control such as teacher preparedness, parental influence, previous experience at a zoo or aquarium or socio-economic situation (Jensen, 2014). The study attempted to tease out some of these variables with the questions on the survey.

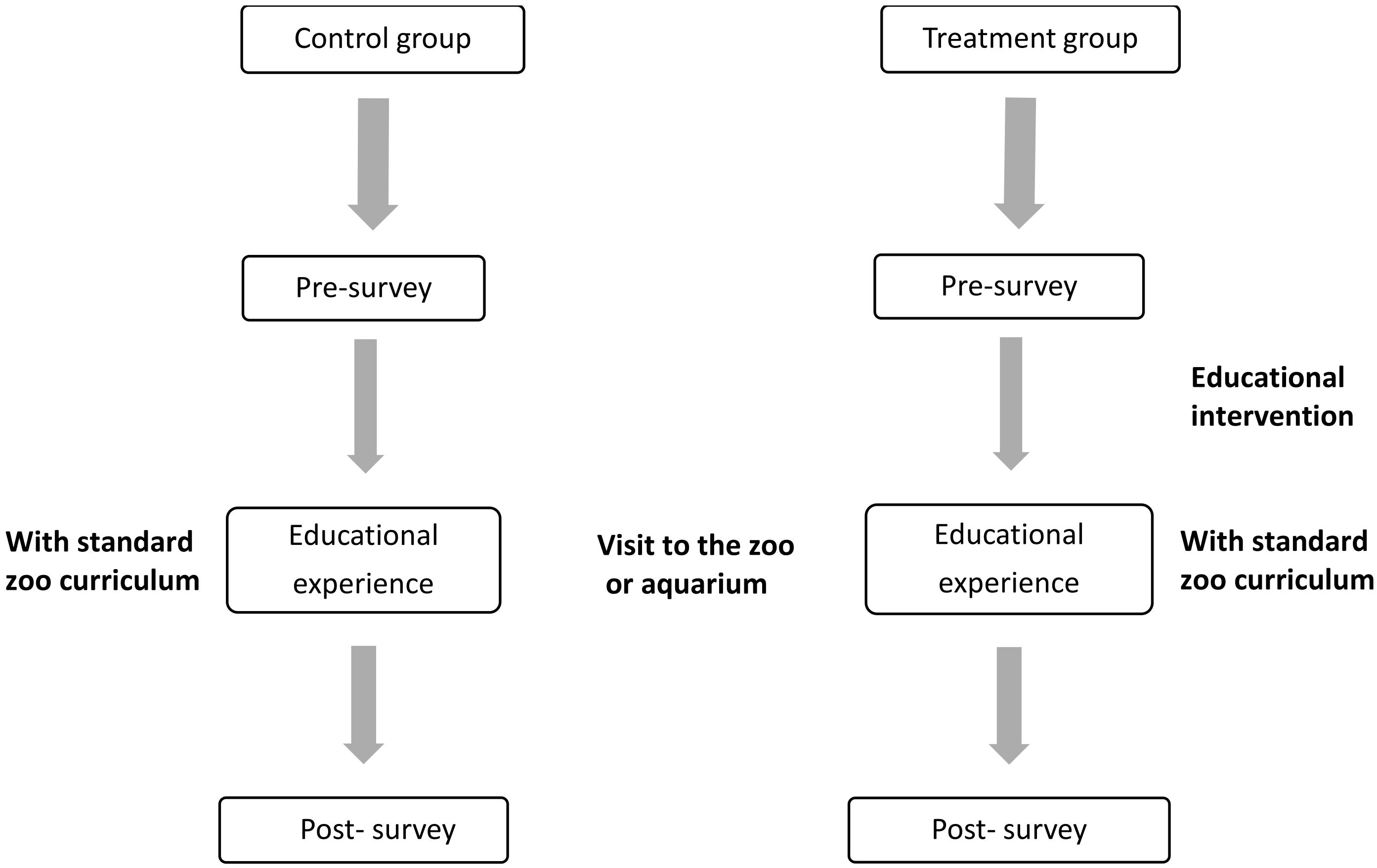


Figure 5.1. Experimental design used during this part of the study, adopted from Lindemann-Matthies and Kamer (2006).

Research sites

The two institutions that participated in the research were Fota Wildlife Park (Fota) in County Cork, Ireland and Dingle Aquarium (Dingle) in County Kerry, Ireland (see Chapters 3 and 4 for specific details of the institutions). The administration of the survey took place at individual schools throughout County Cork prior to a scheduled visit to Fota Wildlife Park or Dingle Aquarium. All staff that conduct tours at Fota or Dingle are highly trained and follow a standard curriculum provided by the zoo or aquarium. The schools that participated in the research received a guided tour of Fota or Dingle of between sixty to ninety minutes in length, which focused on the different animal species on exhibit and conservation in general.

Patrick and Tunnicliffe (2012; p. 97) state that ‘the most important aspect of the zoo visit is to aid children in learning about animals.’ However, while learning during a school tour is certainly a motivation for the excursion, it may not be the most important aspect of many field trips in Ireland. It is the overall experience of learning in a different environment that motivates many Irish school tours, including the social, emotional and fun aspects of the outing (C. Lucey, Principal at one of the participating schools, pers. comm., June, 2018). In Ireland, participation in school tours (by both schools and pupils), is not mandatory, but uptake is almost 100% even though no outside funding is provided; the estimated cost of the Fota trip is €20 per child (C. Lucey, Principal at one of the participating schools, pers. comm., June, 2018). School tour sites are generally chosen by school staff and are based on location and other logistical issues but are not linked to a specific curriculum (C. Lucey, Principal at one of the participating schools, pers. comm., June, 2018).

Participants

The study participants included children in 3rd through 6th class, which in Ireland is approximately 9-12 years of age. This age group was chosen because practically they were more accessible than secondary school children, and it was determined that nine-year old children would be the minimum age able to complete a survey. In total 10 schools consisting of 23 different classes and over 500 students participated in the study. Initially, it was intended to randomly select schools from different locations and socio-economic groups to participate in the research. However, this was not possible, due to the extensive travel and cost that this would have involved. Therefore, the children that participated in the study attended schools that were already booked in for a tour at Fota Wildlife Park or Dingle Aquarium. Upon booking the tour, if the group was the correct age range for the research project and located within County Cork, the school teacher was asked by the Head of Education at Fota or Dingle whether the school would be willing to participate in a research project. When an affirmative answer was given, the details were passed to the reseacher. Next, the researcher contacted the school by phone and then sent a letter giving some basic information about the project, the details of what was required from the school, the researcher’s qualifications and the potential learning benefit to the children

(Oppenheim, 1992). There was 100% agreement by schools that were asked to participate in the research project by the researcher. This yielded a non-probability convenience or opportunistic sample, defined as groups that were easily accessible to the researcher during the research period (Cohen et al., 2007; Wellington and Szczerbinski, 2007). This may be more appropriate than a completely random probability sample for this type of research, because it is representative of children whose parents had the ability to pay for the school tour and whose teacher chose for them to visit Fota or Dingle, rather than being randomly invited by the researcher, which would generally be the case for children visiting a zoo or aquarium on a school tour.

However, once a school agreed to participate in the study it was randomly allocated as a control or treatment school by the researcher, using the random number generator in the Excel package (Table 5.1 and 5.2). If a school brought more than one class to the zoo or aquarium, each class was randomly assigned as a control or treatment group. However, the researcher took advantage of this naturally occurring division of classes to have a control and treatment group from each school when possible. Yet, the researcher had to work within school regulations, and sometimes, because of time constraints, assignment of classes to control or treatment groups was adjusted to suit the school. In this case, there was no way to know if the allocation of a class as treatment or control was in fact random, or if there may have been a selection bias of which the researcher was not aware (Wellington and Szczerbinski, 2007). The schools did not have prior knowledge as to the contents of the survey or the details of the educational intervention.

In order to achieve confidentiality (Cohen et al., 2007), all schools were assigned a code (known only to the researcher) and this combination of letters and numbers is used throughout the research. Following Cohen et al. (2007), because minors were involved in the research, a two-fold approach was taken to obtaining consent. Prior to the research beginning in each school, the teacher (or principal) signed an informed consent letter, which was provided by University College Cork and gave permission for the children to participate in the research project (Appendix, Table A1 this chapter). Next, before the survey was administered, all children were verbally told that participation in the research was voluntary and that they did not have to participate; however, no student ever declined.

Additionally, the project had full approval of the Ethics Committee at University College Cork and the researcher was Garda-vetted.

Table 5.1. Details of the composition of school groups that completed the survey at Fota Wildlife Park.

School	Group ID	Gender	Age	No. of Children in group*	Condition
School 1	FS148	Girls	9 – 10	18	Treatment
	FS149	Girls	9 - 10	19	Control
School 2	FS151	Mix	11 - 12	25	Treatment
	FS152	Mix	11 - 12	25	Control
School 3	FS153	Mix	9 - 10	30	Treatment
	FS154	Mix	9 - 10	30	Treatment
	FS155	Mix	9 - 10	30	Control
School 4	FS157	Girls	11 - 12	34	Treatment
	FS158	Girls	11 - 12	34	Control
School 5**	FS161	Mix	10 - 12	36	Treatment
School 6**	FS162	Mix	10 -11	22	Treatment

*This is the number of children in the class as reported by the teacher, inevitably not all children completed both the pre- and post-survey. **These groups did not answer questions about the ring-tailed lemurs on the survey.

Table 5.2. Details of the composition of school groups that completed the survey at Dingle Aquarium.

School	Group ID	Gender	Age	No. of Children in group*	Condition
School 1	DS141	Mix	11 - 12	19	Treatment
School 2**	DS142	Mix	11 - 12	30	Treatment
	DS143	Mix	11 -12	30	Control
School 3	DS144	Mix	9 - 12	20	Control
School 4**	DS151	Mix	11 -12	30	Control
	DS152	Mix	11-12	24	Treatment
School 5	DS153	Mix	11-12	25	Control
	DS154	Mix	11-12	25	Control
	DS155	Mix	11-12	25	Treatment
	DS156	Mix	11-12	25	Treatment
School 6**	DS161	Mix	11-12	26	Control
	DS162	Mix	11-12	25	Treatment

*This is the number of children in the class as reported by the teacher, inevitably not all children completed both the pre- and post-survey. **This is the same school during different years.

The survey instrument

The survey was designed to assess knowledge about ring-tailed lemurs and penguins, attitudes towards captive animals and learning, and behaviour towards animals held in captivity. A mixed-method approach to data collection was implemented, with both quantitative and qualitative items included on the survey including: thought listing, Likert scales, selected response and open-ended questions (Jensen, 2011, 2014). It was designed over a period of six months and included several trials (Cohen et al., 2007) (Appendix, Table A2 of this chapter). The final version of the survey was completed in the spring of 2014 (Appendix 3, surveys 1-4). The surveys for children visiting Fota Wildlife Park or Dingle Aquarium are almost identical. However, three additional questions about ring-tailed lemurs are included on the Fota survey and wording reflects a visit to a zoo or aquarium. The post-survey was similar to the pre-survey in order to allow for direct comparisons, but the post-survey did not include the questions on demographics, and included the questions 'did you enjoy your visit to the zoo/aquarium?' and 'what was the best part?' Also, the wording of some questions differed to reflect the past tense. The survey instrument was modified slightly during the study with one question added after the first year, and in the second year an error occurred and one question was mistakenly omitted, but the data analysis accounted for these minor changes.

Specifically, the survey included a preliminary section on demographic details: name (for confidentiality this was later changed to a number), gender and age. Additionally, since it is known that visitors construct meaning during an informal science visit from prior knowledge and experience (Adelman et al., 2000; Falk and Dierking, 2000), two questions intended to uncover students' previous experience with nature were included: 'have you been to a zoo or aquarium before?' and 'do you like to watch nature shows on TV?'(similar to Moss et al., 2015).

Next, the survey also included a section on attitude towards zoo/aquarium animals and learning with a 5-point Likert-type response scale including: Strongly Disagree, Disagree, I'm not sure, Agree and Strongly Agree. While there is not necessarily a correct or incorrect answer for the attitude section, the scale data allowed for changes in attitude to be observed. Thus, it is possible to observe if a student developed a more or less positive attitude based on their responses between to two surveys. This was followed by a section on basic knowledge of specific zoo/aquarium species (ring-tailed lemurs and penguins) with one correct response, several incorrect choices, and an 'I'm not sure choice.' The 'I'm not sure choice' was mistakenly left out of the questions about the ring-tailed lemurs on the Fota Wildlife Park survey. Scoring has been adjusted to account for this. The survey concluded with a section intended to uncover visitors' likely behaviour toward zoo animals and their preference for seeing animals with enrichment, with the same Likert-type response scale described above. At the time that the survey was administered, all children were told that enrichment is similar to toys for animals. It was believed that at 9-10 years, children could understand a term like enrichment (Dr M. Esson, Head of Education at Chester Zoo, pers. comm., March, 2015). Qualitative questions were distributed throughout the survey. The ordering of the questions was based largely on pilot work (Oppenheim, 1992). However, to avoid response bias, the ordering of the responses varied and the introduction of a negative statement was included (Falk et al., 2010; Marino et al., 2010).

Qualitative questions (see Table 5.3), which required the students to provide their own response, were limited, and ideally more open-ended questions would have been included on the survey to elucidate children's learning (Dr Andy Moss, Chester Zoo - conservation social scientist, pers. comm., 2014). However, given time constraints and feedback from students and teachers this was not possible. The question 'how can you help zoo animals?' was based on a question asked by Moss et al. (2015) 'Can you think of an action to help save animal species?' It was intended to assess if students developed a sense of environmental empowerment or conservation self-efficacy (a belief in their own ability to help the environment) which has been shown to be of paramount importance in environmental education studies (Hungerford and Volk, 1990; Jensen, 2014). To provide quantitative data for statistical analysis, content analysis or the coding of the open-ended questions was used for all qualitative questions (Krippendorff, 2004; Moss et al., 2015). This was based on pre-existing categories derived from the hypothesis, but also on themes that emerged from the responses given during the two trials at Fota and the trial with a 4th class school group (Oppenheim, 1992; Krippendorff, 2004; Cohen et al., 2007).

Table 5.3. Qualitative questions and descriptions of response categories on the survey.

Question	'How can you help zoo animals?'	
Code	**Response**	**Example**
0	Something negative	They can't be helped; Let them go
1	Other; not related to any of the other categories; I don't know	Become a zoo keeper
2	A vague answer involving taking care of animals	Take care of them; make them comfortable; love them; help them
3	Food related*	Feed them the right food; make sure they have enough to eat
4	Related to enclosures, cages, space or space restrictions	Give them enough space; make bigger enclosures/cages
5	Broad conservation idea	Stop extinction; stop deforestation
6	Child centred positive action	Donate money; pick up litter; adopt an animal
7	Don't tease/annoy/feed zoo animals	Don't touch them; don't laugh at them
8	Enrichment	Give them enrichment or toys to play with
Question	**'When you think of a zoo/ aquarium, what is the first thing that comes to mind?'**	
Code	**Response**	**Example**
0	Something negative	Confined; cages, poor animals, sad
1	Other	Blue
2	Positive, non-zoo related response; food	Ice cream, fun, friends
3	Any response naming a specific animal or something having to do with animals; including 'water' for the aquarium	Cheetah, fish, animals
4	Conservation type response	Conservation, saving wildlife
5	Learning type response	Science; learning
6	A specific mention of the enrichment activity	Toys, bottles, bubbles

Table 5.3 Continued. Qualitative questions and descriptions of response categories on the survey.

Question	**'What is your favorite subject at school?'**	
Code	**Response**	**Example**
0	Something negative	I hate all subjects
1	Other	Friends
2	Activity based	Art, dancing, music, sports
3	Arts	Irish, reading, history, religion
4	STEM subjects	Maths, science, computers
Question	**'What was the best part?'** Post-survey only	
Code	**Response**	**Example**
0	Something negative	Nothing; I hated it
1	Other; I don't know; everything	I loved everything
2	Positive, non-zoo related response; food	Pizza, the bus ride, the gift shop
3	Animals; any response naming a specific animal or something having to do with animals or the zoo/aquarium in general	Animals, touch tank, touring park/aquarium
4	Learning science/conservation	Science was fun; learning conservation/biology
5	A specific mention of the enrichment activity	Making the bottles; making toys, cutting up fruit
6	Specifically mentioning lemurs or penguins	Seeing the penguins; watching the lemurs eat fruit

*This response was based on the assumption that children did not intend to feed the animals themselves. Many children responded with this and it was thought to be a generic type of response referring to animal care in general (e.g. if you have a pet you must ensure that it is fed). If the student clearly indicated that they intended to personally feed zoo animals, this was counted as a negative response.

The educational intervention (EI)

The educational intervention was purposefully designed by the researcher to enhance students' learning in the zoo. It focused on knowledge about ring-tailed lemurs and penguins, children's attitude towards captive animals and learning in the zoo setting, and most importantly, it aimed to change behaviour towards captive animals by minimising incidences of negative behaviour such as: feeding, touching and banging on glass. Specific elements of the EI included, in question and answer format, a PowerPoint presentation (Appendix 4) which described the biology of penguins (and lemurs at Fota Wildlife Park only), threats to their existence in the wild, what life might be like for them in the zoo versus the wild. Smith et al. (2008) and Mann et al. (2018) state that for environmental education to successfully impact a specific behaviour, messages about that behaviour should be clearly communicated to visitors. Therefore, visitor behaviours that were intended to change were described and discussed (e.g. 'you should not feed the lemurs because it could make them sick' or 'you should not bang on the penguins' glass wall because you could disturb or frighten them'). Additionally, emotionally engaging visitors with environmental issues and animals has a positive impact on learning and behaviour (Ballantyne et al., 2001; Myers et al., 2004; Ballantyne, Packer & Sutherland, 2011; Mann et al., 2018), and infant animals elicit emotional responses (Ballantyne et al., 2007). Therefore, the PowerPoint presentation included emotionally appealing pictures, including infants, of the species studied. Throughout the presentation the theme 'science is all around you in the zoo' was emphasised, because the current research considered if zoo-based education programmes are likely to increase students' attitude toward science. The children were introduced to the concept of the scientific method and they were asked to form a hypothesis of what would happen when the penguins received the enrichment device.

Children learn by doing (Dewey, 1998) therefore part of the EI was dedicated to a hands-on activity during which children made enrichment devices for the animals included in the study. The purpose of this was twofold. First, it was intended to improve animal welfare by encouraging the penguins to swim and the lemurs to be more active by providing a non-scheduled feeding/foraging opportunity (Chapter 7). Second, the presence of the enrichment, and more specifically the animals' interest in the enrichment device and potential increased activity, was intended to stimulate children's learning. McPhee et al. (1998) reported that an enrichment device itself had little effect on visitors, but others assert it is the animal behaviour that the device elicits that is interesting to visitors (Wood, 1998; Davey et al., 2005). Here, it was expected that because the children made the enrichment device themselves, and then observed the reaction of the animals that general interest and thus learning would be enhanced. For the ring-tailed lemurs, the children had the opportunity to prepare a scatter feed for the animals. This involved the children cutting up pieces of fruit (apples and bananas) which they later saw the lemurs eating (as suggested by Dr Maggie Esson, Head of Education at Chester Zoo, UK, pers. comm., 2013). For the penguins, the children made an enrichment device, which consisted of varying sizes of plastic bottles with different coloured lids, which the children then filled with shiny bits of paper (Clarke, 2003). The variation in size and colour of the bottles allowed for a discussion about penguins' ability to see in colour and their preference for a certain lid colour or bottle size, which related to scientific observation and forming a hypothesis about the effect of the enrichment. Additionally, at Fota the students made bubble mix which was then blown by machine when they viewed the penguins.

Procedure

The study took place from April-June, which corresponded to the period that most school groups visited the two study sites, during 2014, 2015 and 2016. It was arranged by the researcher to visit each school that agreed to participate in the study before their visit to the zoo/aquarium. To control for Hawthorne effects (the awareness of being studied), students were not told the details of the research (Wellington and Szczerbinski, 2007). Upon arrival at the school the researcher was introduced to the teachers and students participating in the study. Pre-surveys were then administered by the researcher in the school classroom. Ideally, this would have occurred a set number of days before the visit to the zoo/aquarium, but because of the schools' busy schedules this level of standardisation was not possible. However, all pre-surveys were carried out between one and seven days before the school's visit. The classes that were selected as treatment groups participated in the one-hour educational intervention immediately after completing the pre-survey. Following the initial visit from the researcher to the school all groups then attended either Dingle Aquarium or Fota Wildlife Park. Respondents were not informed that they would be given a post-test. Following their visit to the zoo or aquariums, post-surveys were administered by the school teacher a couple of days after the visit (Ballantyne and Packer, 2002). To promote consistency, all teachers were given the same set of instructions about administering the post-survey. Again, it was not possible to standardise the timing of the post-visit survey, but they were all completed within a week of the visit and posted to the researcher in a pre-paid envelope. There was a 100% return rate of the surveys from the schools participating in the study.

Inevitably not every student that completed the pre-survey completed the post-survey and vice versa. Because the study was concerned with tracking learning at an individual level, pre- or post-surveys that did not have a matched-pair were discounted from the study. If certain questions were not answered, the unanswered questions were omitted from the analysis. Following Ballantyne, Packer & Falk (2011), it was aimed to collect at least 150 questionnaires per site, however, a total sample of 501 (242 Fota; 259 Dingle) matched-pair surveys was attained. At Fota, it was originally intended that every school group would view the ring-tailed lemurs. However, since these lemurs are free-ranging this was not always feasible. Given the difficulties with arranging the child-lemur viewings, it was decided in the last year (2016) to leave a visit to the lemurs out of the research. Therefore, schools FS161 and FS162 were not asked questions about lemurs on the survey, since they did not learn about them during the EI and they did not view them during their tour.

Data analysis

General demographics of the study are shown at the beginning of the results section (Tables 5.5). For the Likert scale questions, a high score (5) was considered a favourable response (the most positive answer), which correlated to ‘strongly agree’ when the statement was positive. Thus, when the statement is unfavourable ‘zoo animals are bored,’ scoring was reversed and (5) correlates to ‘strongly disagree.’ For the other questions, a correct response was given a score of (3), I’m not sure (2) and incorrect (1). Where ‘I’m not sure’ was omitted, the question was scored as either correct (2) or incorrect (1). If an individual question was not answered it was given the designation (99) and the total number of questions was adjusted for each section. This scoring system was used consistently throughout the research (Oppenheim, 1992).

For results of each section (knowledge, attitude and behaviour) of the suryvey, data analysis was carried out with the use of R 3.1.2 (R Development Core Team, 2017). To test whether a zoo or aquarium visit had a significant impact on students' learning, linear regression models were constructed to model the scores from student's surveys against various demographic parameters and questionnaire responses (Table 5.4). Separate models were run for each section of the survey (knowledge, attitude and behaviour), in which the difference in total score for that section, between the pre- and post-visit was the dependent variable. Where a statistically significant effect was detected, figures representing the proportion of students' scores to decrease, remain stable or increase for each response options of the statistically significant independent variable are shown because Jensen (2011) and Moss and Esson (2013) state that negative outcomes of educational programmes should be considered.

Table 5.4. The independent variables included in the models.

Independent variables included in the model	Response options	Demographics known or self-reported on survey
Condition	Control/Treatment	Known
Site	Fota Wildlife Park/Dingle Aquarium	Known
School location	Rural/Urban	Known
Social*	DEIS/non-DEIS	Known
School type**	Mixed sex/Girls only	Known
Gender	Male/Female	Self-reported
Previously visited a zoo/aquarium	No/I'm not sure/Yes	Self-reported
Enjoy watching nature shows on TV	No/I'm not sure/Yes	Self-reported

*In Ireland a school may be designated as DEIS (Delivering Equality of Opportunity in Schools) by the Department of Education if it is determined to be educationally disadvantaged. ** No boys only school participated in the study.

Interaction terms were also fitted for condition by each of the demographic parameters to test whether there are condition-specific differences in attitude, knowledge or behaviour trends. All of the assumptions of the models were met. Graphs of the models revealed that the residuals were normally distributed, the variance homogenous across the fitted values of the model and for each individual predictor, and the dependent variables are linearly related to the independent variables. To start, the maximal model, containing all variables, was fitted to the data, and backwards deletion was used using the step function in R (which uses Akaike's Information Criterion [AIC] to delete terms from the model; Crawley, 2007). The least significant parameters remaining in the model were then removed and the deviance checked using ANOVA. Where the deviance was not significantly increased by the removal of that parameter (at the $P<0.05$ level), it remained out of the final model. This process was repeated until the Minimum Adequate Model (MAM), where only parameters significant at the $P<0.05$ level were retained, was achieved (Crawley, 2007).

Finally, the results of individual survey questions are presented using descriptive statistics, where responses are expressed as the proportion of the group that chose each answer. Results were calculated in Microsoft Excel version 2007 and IBM SPSS Statistics 22 and are presented in table format at the end of each section (knowledge, attitude, behaviour and qualitative) (Tables 5.6 - 5.10). For qualitative questions, preliminary results indicated little change from pre- to post-visit or influence from the other variables. Furthermore, while some responses were more favourable than others, there was not a correct or incorrect response for each question, so it was not possible to code the responses as scale data. Therefore, results for the qualitative questions are presented as descriptive data only (Table 5.10). The wording of the questions and the response categories presented on the tables has been modified to fit the tables (Appendix 3 for survey questions and response options). In this chapter of the thesis, because there are several different sections (knowledge, attitude, behaviour and qualitative) with many results, each different section is followed by a discussion pertaining specifically to that section. The demographics section does not include a discussion because it is short section reporting basic facts of the study with some simple information like gender reported from the survey. A brief general discussion follows the results at the end of the chapter.

5.3 Results and discussion

All data were coded by the researcher. To measure inter-coder agreement on qualitative questions a research assistant coded a randomly selected sample of the surveys (n=25). This was then compared to the original coding of the data done by the primary researcher using the Cohen's kappa statistic. An average kappa value of 0.88 ($p < 0.001$) was achieved (Appendix, Table A3 of this chapter for results from individual questions), indicating a high level of inter-coder agreement (Jensen, 2014). Cronbach's alpha was used to measure the internal consistency of the survey instrument and indicated a reliable level of internal consistency (α=0.717) (Cohen et al., 2007).

5.3.1 Demographic results

Results of demographic questions are presented below (Table 5.5). Responses are expressed as the proportion of the group that chose a given answer or were known to the researcher.

Table 5.5. Demographic variables of the study participants presented as control and treatment groups.

Demographics Total (n = 501)	Control group (n = 214)	Treatment group (n = 287)
Site		
Fota	0.37	0.56
Dingle	0.63	0.44
Location		
Urban	0.85	0.76
Rural	0.15	0.24
Social		
Non DEIS	0.93	0.95
DEIS	0.07	0.05
School type		
Boys only	0.00	0.00
Girls only	0.19	0.15
Mixed	0.81	0.85
Age*		
9	0.17	0.20
10	0.05	0.07
11	0.61	0.34
12	0.17	0.35
13	0.01	0.04

Table 5.5 Continued. Demographic variables of the study participants presented as control and treatment groups.

Gender*	**Control group**	**Treatment group**
Male	0.41	0.44
Female	0.59	0.56
Zoo/Aquarium before[1,2]*		
No	0.15	0.09
Not sure	0.05	0.04
Yes	0.80	0.87
Nature shows on TV[2,]*		
No	0.27	0.25
Not sure	0.09	0.10
Yes	0.64	0.65
Enjoyed the day[3,]*		
No	0.01	0.02
Not sure	0.03	0.05
Yes	0.95	0.93

1, This question was also analysed by site. Students at Fota reported (No 0.06, Not sure 0.01, Yes 0.93); Dingle (No 0.17, Not sure 0.08, Yes 0.75) for having visited a zoo/aquarium before.
2, from the pre-survey, 3, from the post-survey ***** = Self-report data

5.3.2 Knowledge results and discussion

General linear model

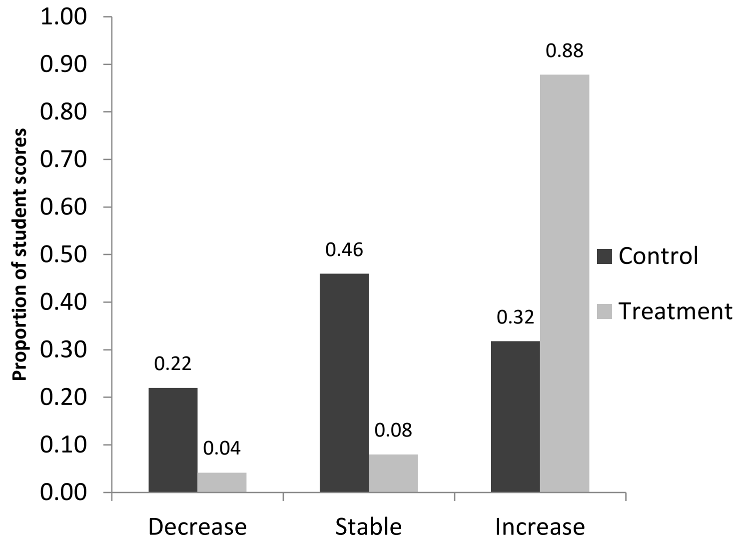
The results of the general linear model for knowledge revealed that condition, site, location and school type significantly affected knowledge score. When non-significant variables (Appendix, Table A4 of this chapter) were removed from the model in a backwards stepwise approach and the Minimum Adequate Model was achieved, condition ($p<0.001$) (Figure 5.2A), site ($p<0.001$) (Figure 5.2B), location ($p<0.001$) (Figure 5.2C) and school type ($p=0.002$) (Figure 5.2D) remained as significant predictors of knowledge scores. Interactions occurred between condition:site ($p<0.001$) (Figure 5.3A), condition:location ($p<0.001$) (Figure 5.3B), condition:school type ($p=0.024$) (Figure 5.3C).

Overwhelmingly, children in the treatment group (88%) had an increase in knowledge between pre- and post-test, compared to only 32% of the control group (Figure 5.2A).

Students visiting Fota (79%) were more like than those at Dingle (50%) to have an increase in knowledge after their visit (Figure 5.2B). An interaction was discovered between condition and site and it was discovered that more children in the Fota treatment group (94%) than the Dingle treatment group (80%) had an increase in knowledge from pre- to post-test (5.3A). The children most likely to score lower in the post-test then the pre-test (decrease in knowledge as a result of the visit) were children in the Dingle control group (24%) compared to 19% of the Fota control group (Figure 5.3A). 54% of the Dingle control group neither lost or gained in knowledge as a result of their aquarium visit, compared to 34% of the Fota control group (Figure 5.3A).

Additionally, location affected knowledge scores with rural schools (73%) having a slightly higher chance of having an increase in knowledge than urban schools (62%) (Figure 5.2C). However, location also interacted with condition. Increases in knowledge appear similar for urban and rural schools in treatment and control groups, but rural control groups (34%) are more likely to have a decrease in knowledge that urban control groups (20%) (Figure 5.3B). Girls-only schools had the highest increases (71%) and lowest decreases (10%) in knowledge compared to mixed-schools at 62% and 12% respectively (Figure 5.2D). When considered together with condition, it was found that girls-only schools who experienced the EI had a 98% chance at increasing their knowledge level and a zero percent chance of a decrease from pre-test to post-test, compared to mixed-schools at 86% and 5% respectively (Figure 5.3C).

A.



B.

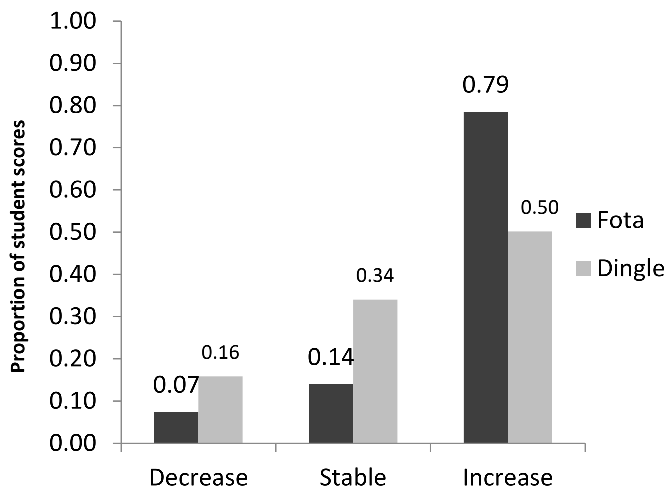
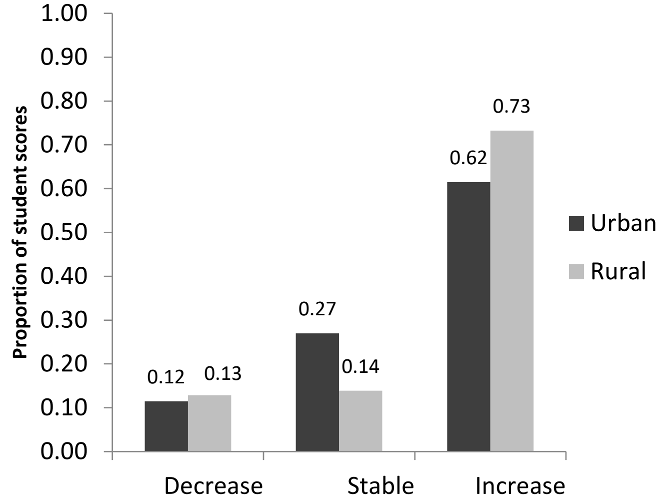


Figure 5.2. The proportion of students whose knowledge scores decreased, remained stable or increased between pre- and post-survey for A) control or treatment groups, B) at Fota or Dingle.

C.



D.

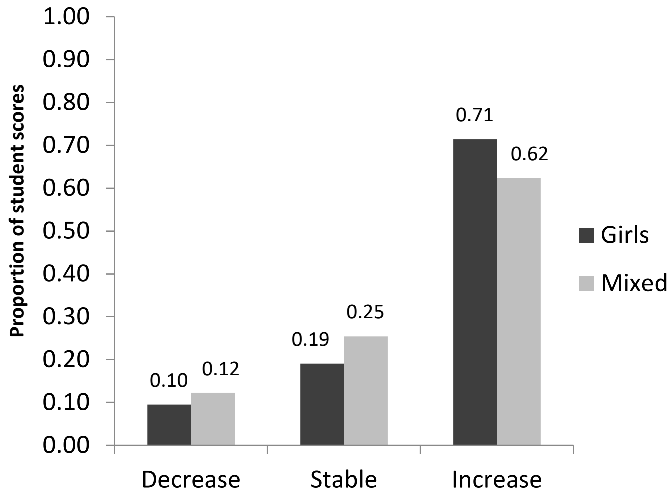
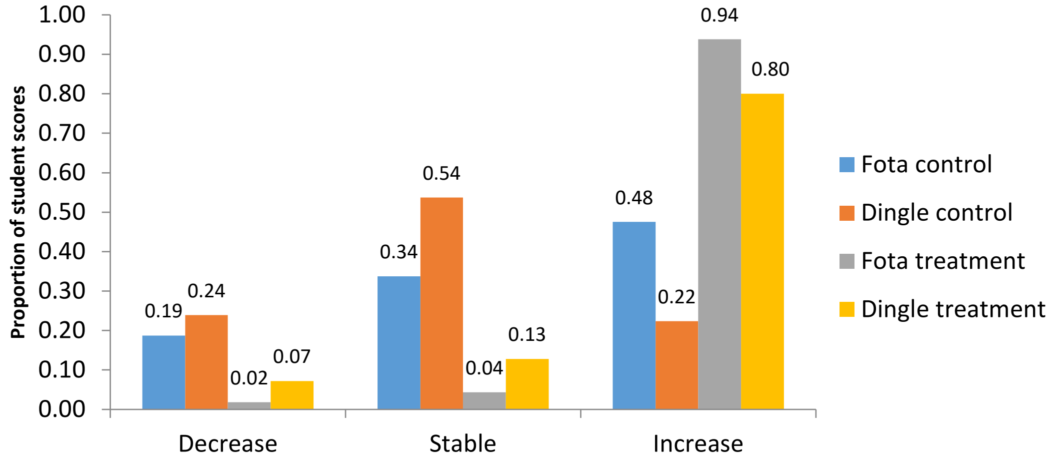
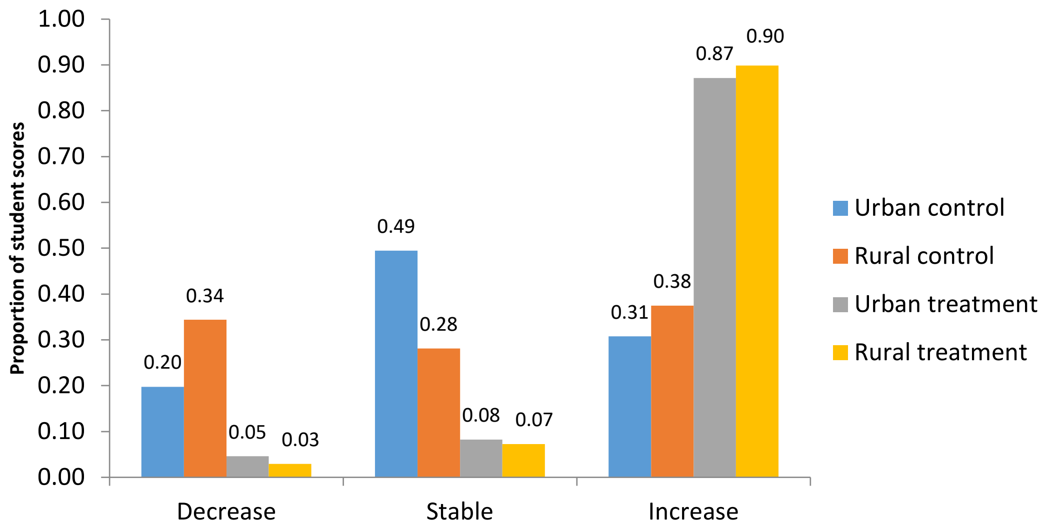


Figure 5.2 Continued. The proportion of students whose knowledge scores decreased, remained stable or increased between pre- and post-survey for C) urban or rural schools and D) girls-only or mixed-sex schools.

A.



B.



C.

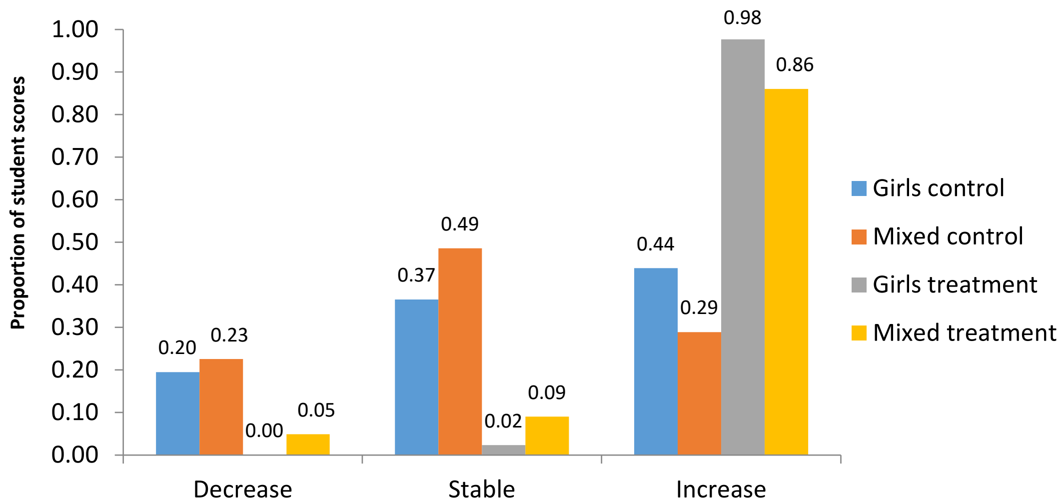


Figure 5.3. The proportion of students whose knowledge scores decreased, remained stable or increased for treatment and control groups between pre- and post-survey at A) Fota or Dingle B) urban or rural schools and C) girls-only or mixed-sex schools.

Descriptive statistics

Table 5.6. Results of individual questions about ring-tailed lemurs (RTLs) from the knowledge section of the survey administered to groups visiting Fota Wildlife Park presented as control and treatment groups.

Knowledge questions Ring-tailed lemurs	Control group		Treatment group	
Responses:	Incorrect	Correct	Incorrect	Correct
1) RTLs come from? PRE	0.36	0.64	0.40	0.60
RTLs come from? POST	0.25	0.75	0.13	0.87
Responses:	Incorrect	Correct	Incorrect	Correct
2) RTLs are endangered because of? PRE	0.71	0.29	0.77	0.23
RTLs are endangered because of? POST	0.66	0.34	0.31	0.69
Responses:	Incorrect	Correct	Incorrect	Correct
3) The most important part of a RTL's diet? PRE	0.80	0.21	0.88	0.12
The most important part of a RTL's diet? POST	0.79	0.20	0.38	0.62

Question 1) Incorrect responses include: Africa, South America, New Zealand, Sri Lanka; Correct response: Madagascar
Question 2) Incorrect responses included: Drought, Global Warming, Fire, Hunting; Correct response: Deforestation
Question 3) Incorrect responses included: Food from visitors, Meat, Fruit, Flowers; Correct response: Leaves

Table 5.7. Results of individual questions about penguins from the knowledge section of the survey administered to groups visiting Fota Wildlife Park and Dingle Aquariums presented as control and treatment groups.

Knowledge questions Penguins	Control group			Treatment group		
Responses:	Incorrect	NS	Correct	Incorrect	NS	Correct
1) Penguins are? PRE	0.38	0.02	0.60	0.38	0.04	0.58
Penguins are? POST	0.34	0.02	0.64	0.08	0.02	0.90
Responses:	Yes	NS	No	Yes	NS	No
2) Penguins can fly? PRE	0.02	0.04	0.94	0.04	0.02	0.94
Penguins can fly? POST	0.01	0.03	0.95	0.01	0.00	0.98
Responses:	Incorrect	NS	Correct	Incorrect	NS	Correct
3) Where do penguins live? PRE	0.50	0.11	0.39	0.55	0.13	0.32
Where do penguins live? POST	0.48	0.07	0.45	0.24	0.03	0.73
Responses:	Incorrect	NS	Correct	Incorrect	NS	Correct
4) What climate do penguins live in? PRE	0.88	0.01	0.11	0.82	0.00	0.18
What climate do penguins live in? POST	0.80	0.00	0.20	0.16	0.01	0.84

Question 1) Incorrect responses include: Marine mammals, Fish; NS = Not sure; Correct response: Birds
Question 2) Incorrect response include: Yes; NS = Not sure; Correct response: No
Question 3) Incorrect responses include: Northern Hemisphere, Both; NS = Not sure; Correct response: Southern Hemisphere
Question 4) Incorrect responses include: Warm, Cold; NS = Not sure; Correct response: Both

The fact that this study showed that knowledge scores were more likely to increase in the treatment group from pre- to post-test is an encouraging, but not a surprising result. The educational intervention followed several of the recommendations outlined by Ballantyne and Uzzell (1994) for the enhancement of informal learning experiences. The EI used in the current study was specifically designed for children of the study age group (Ballantyne and Uzzell, 1994), rather than the general curriculum applied to all visitors. It involved an interpretive presentation, including an in-depth question and answer session with the children about the study species, as well as a hands-on activity, both of which have been shown to enhance learning (Ballantyne and Uzzell, 1994; Visscher et al., 2009). Furthermore, the first part of the EI took place in a classroom setting, which may be more conducive to learning compared to learning while touring the park (Ballantyne and Uzzell, 1994; Dillon et al., 2006). Additionally, as students in the treatment group viewed the animals on their tour of the zoo, they had the opportunity to see them interacting with the enrichment device that they had made for them, allowing environmental learning to occur through direct observation and experience in a real-world setting, which is known to enhance visitors' experience (Ballantyne and Uzzell, 1994; Ballantyne and Packer, 2002; Ballantyne, Packer & Sutherland, 2011).

For individual questions (see Table 5.7), the largest increase in a correct response occurred with the question 'what climate to penguins live in?' Most students answered incorrectly on the pre-survey. Many children, probably influence by the media (Wagoner and Jensen, 2010), believed that penguins live in cold climates only. However, on the post-survey 84% of children in the treatment group answered this question correctly compared to only 20% in the control group. Most children in both groups knew on the pre-survey that penguins cannot fly, so little difference occurred with responses for this question. For the control group, almost no shift occurred in response to the question 'what (type of animal) are penguins?' with 34% of control group students still answering this incorrectly compared to only 8% of the treatment group on the post-survey. 'Where do penguins live?' was difficult for both groups, but on the post-survey 73% of treatment groups children answered this correctly compared to 45% of control group children. Similar trends occurred for individual questions about the ring-tailed lemurs (Table 5.6). The question regarding lemurs' diet produced the largest shift in responses with 42% more children in the treatment group than control group answering this correctly on the post-survey.

That knowledge appeared more likely to increase at Fota than at Dingle between pre- and post-test is a more complex issue, which may be attributed to the novelty of the setting. More students at Fota Wildlife Park had been to a zoo before than those at Dingle Aquarium who had been to an aquarium before. This confirms the previous research of Ballantyne and Packer (2002), who that reported that students were more excited about an excursion if they had not previously visited the site, but the added excitement of a novel setting can also lead to distraction and interference with learning (Falk and Balling, 1982; Dillon et al., 2006). Furthermore, it was perceived by the researcher that the students thought that Dingle itself was a more exotic and less familiar location than Fota Wildlife Park (personal observation by researcher) perhaps because of its distance from Cork, the main location of the schools in this research. Furthermore, the entrance to the penguin viewing area is quite dark with UV-A lights, and this may have excited and distracted the students. While the curriculum and design of the tours and Fota and Dingle appeared similar to the researcher, differences may have existed with staff teaching strategy at the sites that also accounted for the reduced scores at Dingle Aquarium.

Additionally, location of the school affected knowledge scores. This could be due to undetermined differences between rural and urban schools. Or, it is possible that children at rural schools are more accustomed to nature and animals, and perhaps a visit to a zoo did not hold the same appeal for them as children in urban settings, though previous research tends to suggest the opposite, i.e. that previous experience with nature can lead to greater affinity towards the environment (Palmberg and Kuru, 2000). However, if rural students did not engage as much as urban children during the visit they may have scored lower on the knowledge section of the post-test. This pattern was generally the same for children visiting Fota or Dingle. The needs and expectations of different groups is something that teachers and staff could be made aware of in the future.

School type also affected knowledge outcomes, with children from girls-only schools most likely to have an increase in knowledge after the visit. Previous research has found that single sex education can benefit students, particularly girls (Lee and Bryk, 1986), and perhaps the current research has uncovered an advantage of a single sex school tour. However, similar to Jensen (2011), in the current study student gender (male, female) did not have an effect on knowledge scores. Additionally, it must be noted that there were no boys-only schools and the sample of girls-only groups (n =4) was quite small.

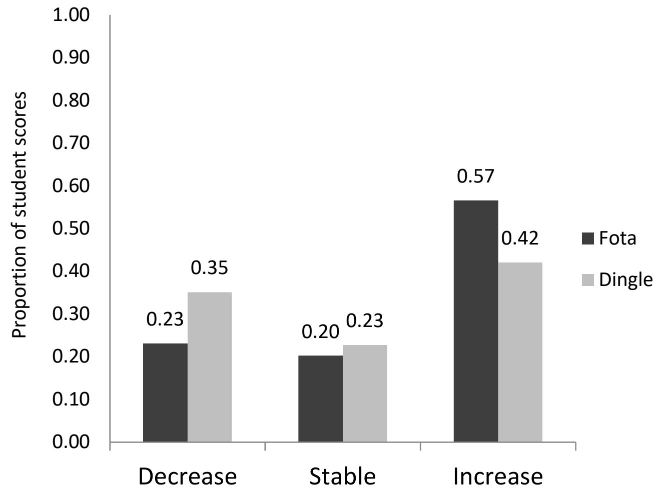
5.3.3 Attitude results and discussion

General linear model

The general linear model for attitude showed that condition did not have a significant effect on attitude score (Appendix, Table A5 of this chapter). However, both site (p=0.003) (Figure 5.4A) and gender (p=0.031) (Figure 5.4B) were found to be statistically significant. No statistically significant interactions occurred.

57% of students visiting Fota Wildlife Park showed an increase in attitude score from pre- to post-test, compared to 42% that visited Dingle Aquarium (Figure 5.4A). Additionally, at Dingle it was more likely (35%) than at Fota (23%) that attitude would decrease after the visit (Figure 5.4A). Those whose attitude remained unchanged was similar between the two sites (Figure 5.4A). 54% of female students experienced an increase in attitude score from pre- to post-visit compared to 43% of male students (Figure 5.4B). Male students were also more likely (38%) than female students (23%) to have a decrease in attitude after the visit (Figure 5.4B).

A.



B.

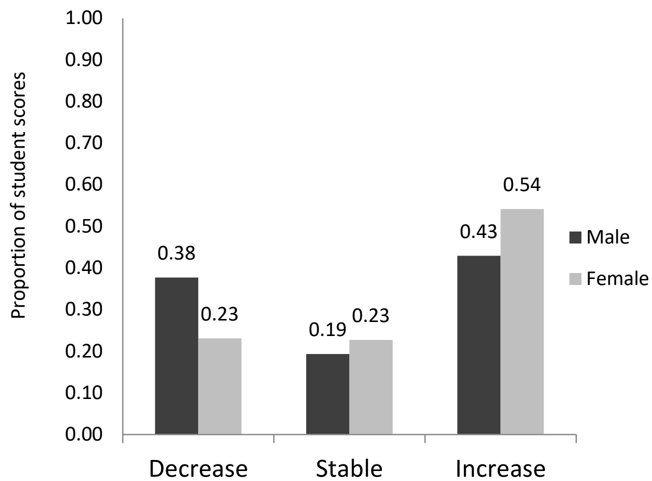


Figure 5.4. The proportion of students whose attitude scores decreased, remained stable or increased between pre- and post-survey at A) Fota or Dingle and B) for male and female students.

Table 5.8. Results of individual questions from the attitude section of the survey administered to groups visiting Fota Wildlife Park and Dingle Aquariums presented as control and treatment groups.

Attitude questions	Control group					Treatment group				
Responses:	SA	A	NS	D	SD	SA	A	NS	D	SD
Zoo animals are happy? PRE	0.07	0.49	0.27	0.14	0.04	0.08	0.42	0.33	0.14	0.02
Zoo animals are happy? POST	0.18	0.48	0.24	0.07	0.03	0.14	0.51	0.28	0.05	0.03
Zoo animals are bored? PRE	0.07	0.26	0.24	0.35	0.08	0.04	0.26	0.33	0.29	0.09
Zoo animals are bored? POST	0.07	0.21	0.26	0.31	0.14	0.06	0.25	0.26	0.33	0.09
Looking forward to learning about animals? PRE	0.54	0.37	0.07	0.02	0.00	0.52	0.39	0.06	0.02	0.01
Looking forward to learning about animals? POST	0.56	0.36	0.03	0.03	0.01	0.51	0.38	0.08	0.02	0.01
Looking forward to learning science? PRE	0.25	0.35	0.14	0.18	0.07	0.27	0.32	0.23	0.11	0.05
Looking forward to learning science? POST	0.29	0.32	0.18	0.11	0.10	0.35	0.33	0.18	0.09	0.05

SA = Strongly agree, A = Agree, NS = I’m not sure, D = Disagree, SD = Strongly disagree

Ballantyne and Packer (2002) found that nature-based trips of several hours enhanced students' attitude toward the environment. Yet, it the current study, change in attitude was limited after an educational experience with only site and gender significantly affecting total attitude scores. Interestingly, participation in the educational intervention did not affect students' attitude towards zoo animals and learning. This is in contrast to Anderson et al. (2003) who found that visitor participation in an otter training session positively affected visitors' perceptions of zoo animals. However, one of the important elements of the otter training session was that the animals became more active during the session (Anderson et al., 2003), and unfortunately in the current study the animals generally did not become more active during the viewing sessions with the treatment group than the control group (see Chapter 7).

Although, a brief educational experience may not be enough to influence long held beliefs (Adelman et al., 2000; Falk and Dierking, 2000), the majority of students (57%) visiting Fota scored higher for attitude after the visit. While there may be many factors which affect students' attitude, the clear difference in attitude between sites uncovered in this study may be attributable to the different style of enclosure design at the two sites. Previous research has indicated that visitors, including children, like to see animals in naturalistic enclosures (Rhoads and Goldworthy, 1979; Tofield et al., 2003). Fota Wildlife Park includes many free-ranging or semi free-ranging species, and in general is an outdoors experience in a natural environment for visitors. In contrast, Dingle Aquarium is a generally indoors experience where the study species do not have access to the outside; the penguin enclosure consists entirely of artificially lighting and includes many artificial materials, though they imitate a naturalistic environment. It is likely that this difference in enclosure design is responsible for the diminished attitude detected at Dingle Aquarium (Sommer, 1972; Finlay et al., 1988). Yet, result from the descriptive statistics (Table 5.8) show that most students agreed or strongly agreed that zoo animals were happy and there is a slight increase in this from pre- to post-test for both treatment and control groups. The results are slightly more ambiguous for the question – 'do you think zoo animals are bored?' Of course, this question required students to reverse the response categories, and it is possible that some students were not able to do this.

Gender was also found to affect attitude at the zoo, with girls scoring better than boys in attitude after the visit. This is similar to the difference seen in cognitive knowledge gain between girls-only and mixed gender schools, it is possible that girls and boys experience animals differently (Tunnicliffe, 1998; Myers et al., 2004). Myers et al. (2004) discovered that women are more emotional and empathetic while viewing animals than men, but women were more likely to feel disgust (towards a snake), but also more attraction and wonder than men while viewing animals. Additionally, Tunnicliffe (1998) reported that girls make more emotive comments and boys are more likely to make factual comments while viewing animals. These results suggest that further investigation into the gender dimension in the zoo setting may be worthwhile and is something that zoos should be made aware of.

Many countries are experiencing a 'swing away from science,' and positive attitudes generated from science education can generate public engagement and appreciation of science (Osborne et al., 2003; p. 1050). Therefore, it was considered if a visit to a zoo or aquarium could help to influence children's attitude toward science. The results from the individual questions (Table 5.8) indicated that most students agreed or strongly agreed that they were looking forward to learning about animals. The results for the question about learning science were similar, though fewer children strongly agreed that they were looking forward to learning science. In the treatment group, there was an increase in students who strongly agreed they were looking forward to learning science from 27% (pre) to 35% (post), which was the largest difference detected for that question. This concurs with the findings of Whitehouse et al. (2014), who reported that a specially designed intervention (in their study a computer game) increased interest in science in zoo visitors. Yet, it seems that generally students' attitude to learning about animals and science was not something that was greatly influence by the visit, with one child in the control group writing on their survey 'we didn't learn any science.' Enhancing students' attitude toward science and directing more of the visit towards science topics in the zoo is an area that zoos could focus on, since zoos are in a position to promote science engagement to a wide audience (Whitehouse et al., 2014). Yet, Osborne et al. (2003) summarised the work of Ajzen and Fishbein (1980) and cautioned that attitudes are enduring and difficult to change once formed.

5.3.4 Behaviour results and discussion

General linear model

The general linear model for behaviour revealed (Appendix, Table A6 of this chapter) that condition ($p=0.025$) (Figure 5.5A), site ($p<0.001$) (Figure 5.5B) and school type ($p=0.019$) (Figure 5.5C) significantly affected behaviour scores. A significant interaction occurred between condition:site ($p<0.001$) (Figure 5.6).

Children in the treatment group were more likely (51%) to have an increase in their behaviour score from pre- to post-test than those in the control group (34%) (Figure 5.5A). Similar to knowledge and attitude scores, again children visiting Fota (58%) were more likely than those visiting Dingle (31%) to have an increase in behaviour scores (Figure 5.5B). A significant interaction occurred which indicated that children in the treatment group visiting Fota were the most likely to have an increase (64%) in their behaviour score and the least likely to have a decrease (11%) (Figure 5.6). In contrast only 9% of children in the Dingle control group showed an increase in behaviour score from pre- to post-test compared to 72% that had a decrease (Figure 5.6). Additionally, girls-only schools (57%) were more likely than mixed-sex schools (41%) to have an increase in behaviour scores (Figure 5.5C).

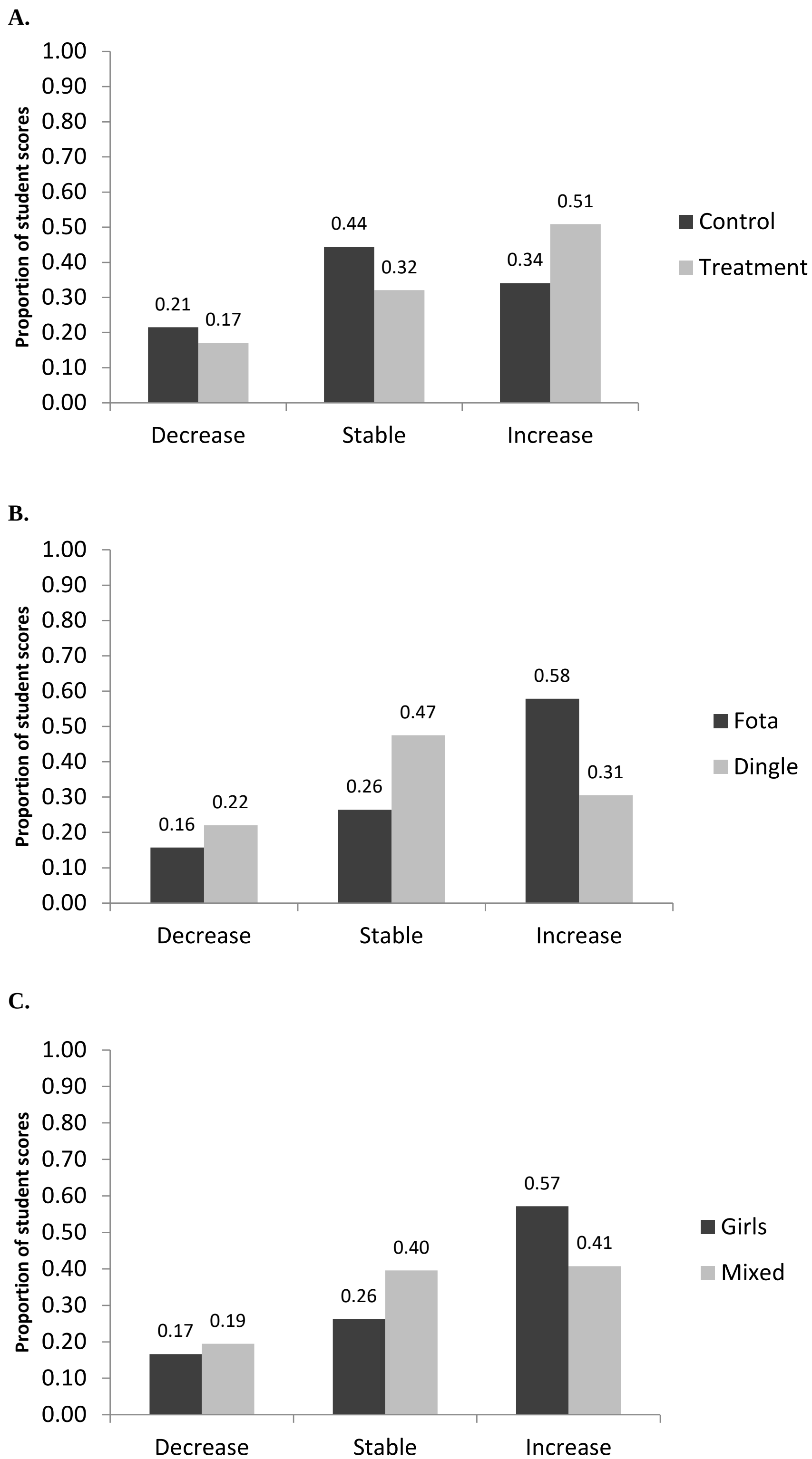


Figure 5.5. The proportion of students whose behaviour scores decreased, remained stable or increased between pre- and post-survey for A) control or treatment groups B) at Fota or Dingle or C) at girls-only or mixed-sex schools.

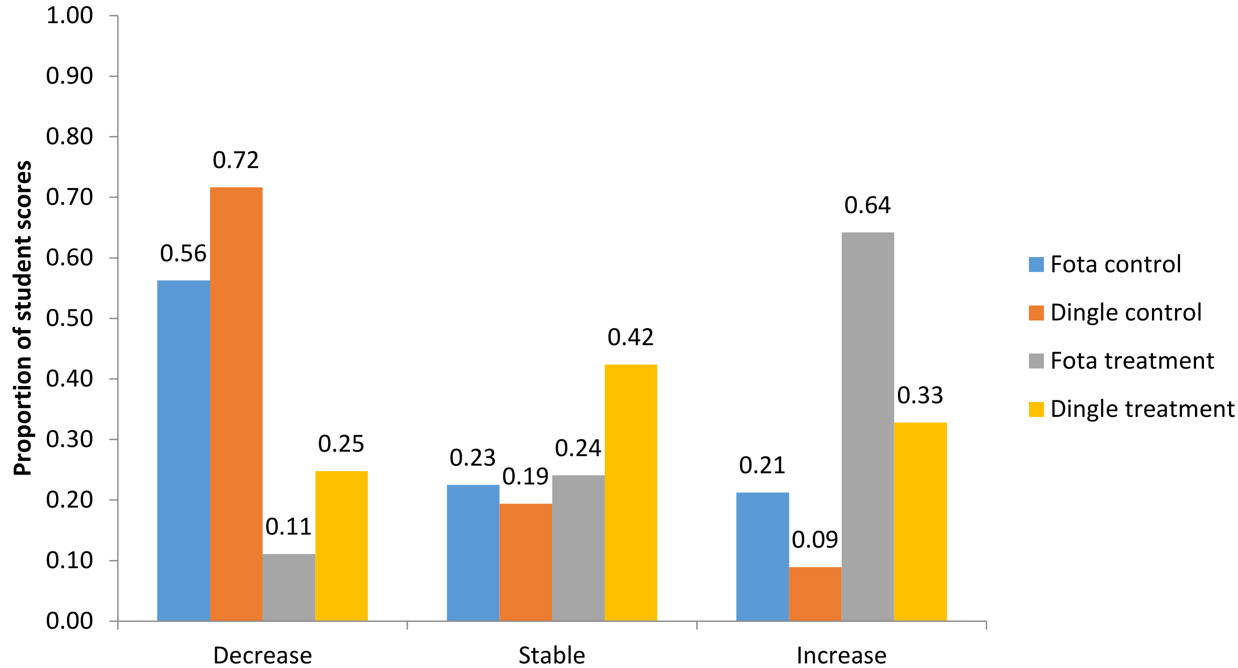


Figure 5.6. The proportion of students whose behaviour scores decreased, remained stable or increased at Fota Wildlife Park or Dingle Aquarium for treatment and control groups between pre- and post-survey.

Descriptive statistics

Table 5.9. Results of individual questions from the behaviour section of the survey administered to groups visiting Fota Wildlife Park and Dingle Aquarium presented as control and treatment groups.

Behaviour questions	Control group					Treatment group				
Responses:	SA	A	NS	D	SD	SA	A	NS	D	SD
*Allowed to feed free-ranging animals? PRE	0.15	0.18	0.11	0.28	0.29	0.12	0.26	0.14	0.28	0.20
*Allowed to feed free-ranging animals? POST	0.09	0.18	0.11	0.20	0.43	0.04	0.13	0.10	0.30	0.43
*Allowed to touch free-ranging animals? PRE	0.09	0.17	0.17	0.29	0.28	0.09	0.29	0.15	0.31	0.17
Allowed to touch free-ranging animals? POST	0.09	0.20	0.11	0.31	0.29	0.05	0.12	0.15	0.36	0.33
**It is okay to bang on glass? PRE	0.01	0.04	0.04	0.27	0.64	0.02	0.01	0.01	0.19	0.78
It is okay to bang on glass? POST	0.02	0.03	0.04	0.25	0.66	0.01	0.02	0.06	0.19	0.73
I like to see enrichment? PRE	0.42	0.41	0.13	0.04	0.01	0.39	0.39	0.15	0.05	0.01
I like to see enrichment? POST	0.49	0.32	0.14	0.05	0.00	0.45	0.37	0.15	0.01	0.02

SA = Strongly agree, A = Agree, NS = I'm not sure, D = Disagree, SD = Strongly disagree; * = Fota Wildlife Park only, ** = Dingle Aquarium only

While an increase in knowledge or an improvement in attitude can be considered a positive outcome of a zoo visit, the ultimate goal of zoo education is positive pro-environmental behaviour change or action (Hungerford and Volk, 1990; Ogden and Heimlich, 2009). However, it has proven difficult, not only to show a direct link between a zoo visit and a changed behaviour, but also to measure the change in behaviour (Dierking et al., 2004; Smith et al., 2008). Yet, the results from this research indicate that behaviour scores were affected by a visit to the zoo or aquarium.

Condition and site affected behaviour scores. Again, it is likely that this was influenced by the different type of enclosures and the fact that those children who participated in the EI specifically learned about the behaviour that was expected to change (Smith et al., 2008). Similar to the findings for knowledge, girls only schools were more likely than mixed schools to have an increase in behaviour scores. The gender difference in regard to learning in the zoo is an area that has received very little attention (Randler et al., 2007), but the results found here suggest that it is certainly something that should be considered by zoos and future researchers.

Results from the individual questions (Table 5.9) indicate that after the visit to Fota, children thought it was worse (more strongly disagreed) to feed the animals (43%) than to touch them (approximately 30%), suggesting that perhaps the children perceived that feeding is more invasive than touching. For both of these questions in both control and treatment groups responses improved from pre- to post-survey, but children in the treatment group had larger increases in 'strong disagree' between pre- and post-survey. Ballantyne and Packer (2002) also reported that after an outdoor experience, children wrote in their survey responses not to feed animals or frighten wildlife. At Dingle Aquarium, most children strongly disagreed that it is okay to bang the glass (over 60% for control groups and over 70% for treatment groups). However, a 5% decrease occurred in children in the treatment group at Dingle after the visit, who strongly disagreed to banging on the glass. The reason for this is unclear, but it is possible that participation in the EI alerted children to the fact that banging on the glass was possibly a way to get an animal's attention and they considered banging less bad. Results between control and treatment groups pre- and post-test for the enrichment question are relatively similar.

There is a slight increase in children in the control group (49%) versus the treatment group (45%) who strongly agree that they would like to see animals with enrichment. It is likely that some children in the control group were aware that their classmates in the treatment group got to see the animals interacting with ‘toys,’ and thus they too wanted to see it. Within the treatment group, there was a slight increase (6%) in response from pre- to post-survey of children who strongly agreed they would like to see animals with enrichment. Had the animals been more active when the enrichment was present, there may have been a larger increase.

In this part of the study, the survey measured intended behaviour towards zoo animals, which is not as suitable as measuring actual behaviour. Moss et al. (2015) found an increase in visitors understanding of actions to protect biodiversity from pre- to post-test, but caution that an increase in knowledge of actions is not necessarily an indicator that behaviour will change. Dierking et al. (2004) also observed that it is well known that what people report that they intend to do and their actual actions are not necessarily similar, especially in regard to conservation related actions. However, elsewhere in the present study actual on-site behaviour of children was observed and recorded (see Chapter 7).

5.3.5 Qualitative questions results and discussion

The question ‘how can you help zoo animals?’ produced the largest variation in student responses between control and treatment groups and pre- and post-survey (Table 5.10). On the post-survey, 20% of students responded with ‘don’t annoy animals’ versus 9% on the pre-survey (Figure 5.7). However, on the post-survey taking condition into account, 24% of treatment respondents said ‘don’t annoy animals’ versus 15% in the control group (Table 5.10). There was also a 7% decrease in children answering with food related responses and a 6% increase in enrichment related responses on the post-survey (Figure 5.7).

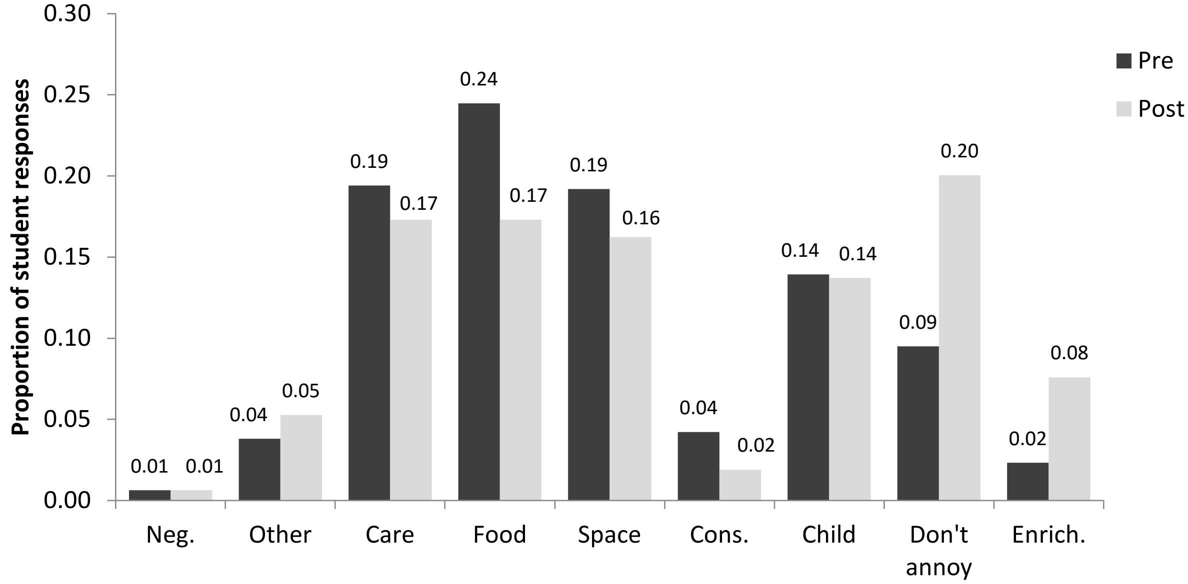


Figure 5.7. Student responses given to the question ‘how can you help zoo animals?’ on the pre- and post-survey.

Table 5.10. Results from the qualitative questions on the survey administered to groups visiting Fota Wildlife Park and Dingle Aquarium presented as control and treatment groups.

1) How can you help zoo animals?										
Control group	Responses:	Neg.	Other	Care	Food	Space	Cons.	Child	Don't Annoy	Enrich
PRE		0.01	0.04	0.19	0.27	0.19	0.03	0.12	0.11	0.05
POST		0.01	0.05	0.21	0.18	0.17	0.02	0.15	0.15	0.06
Treatment group	Responses:	Neg.	Other	Care	Food	Space	Cons.	Child	Don't Annoy	Enrich
PRE		0.00	0.04	0.21	0.24	0.20	0.05	0.16	0.09	0.01
POST		0.00	0.06	0.15	0.17	0.16	0.01	0.13	0.24	0.09

2) When you think of a zoo/ aquarium, what is the first thing that comes to mind?								
Control group	Responses:	Neg.	Other	Fun	Animals	Cons.	Learning	Enrich.
PRE		0.01	0.03	0.11	0.77	0.05	0.02	0.02
POST		0.02	0.03	0.14	0.73	0.03	0.02	0.03
Treatment group	Responses:	Neg.	Other	Fun	Animals	Cons.	Learning	Enrich.
PRE		0.01	0.04	0.15	0.72	0.04	0.01	0.02
POST		0.02	0.05	0.10	0.78	0.01	0.01	0.03

Table 5.10 Continued. Results from the qualitative questions on the survey administered to groups visiting Fota Wildlife Park and Dingle Aquarium presented as control and treatment groups.

3) What is your favourite subject at school? Control group Responses:	Neg.	Other	Activity	Arts	STEM
PRE	0.00	0.00	0.48	0.19	0.32
POST	0.00	0.01	0.49	0.18	0.32
Treatment group Responses:	Neg.	Other	Activity	Arts	STEM
PRE	0.00	0.01	0.52	0.19	0.29
POST	0.00	0.02	0.55	0.16	0.27

4) What was the best part? Control group Responses:	Neg.	Other	Pos. non-zoo	Animals	Learning	Enrich	Lemurs Penguins
POST	0.01	0.08	0.01	0.67	0.01	0.00	0.22
Treatment group Responses:	Neg.	Other	Pos. non-zoo	Animals	Learning	Enrich	Lemurs Penguins
POST	0.00	0.06	0.03	0.56	0.04	0.01	0.29

Responses correspond to those presented in Table 5.3, but have been abbreviated to fit the table.

Responses from the qualitative questions produced little variation in response, even in the treatment group. This may be further evidence that it is difficult to change long-held beliefs and opinions (Adelman et al., 2000). Equally, it might indicate that the questions did not allow for the students to amply express their thoughts or they did not have the time or motivation to do so. Interviews were considered and might be the best way to gain insight into a person's experience and understanding, though this can be difficult with children (Cohen et al., 2007), and was not possible in the current study.

For the question, 'how can you help zoo animals?' the aim was to have more specific responses like 'adopt an animal,' 'have a fundraiser,' 'don't litter,' 'don't shout at them,' and 'don't feed them,' and fewer responses like 'give them enough food' and 'care for them', since Mann et al. (2018) state that visitors who remembered specific actions after a zoo visit, were more likely to take pro-environmental action than those that only remembered a general action. There was a noticeable decrease in students responding with a food related response after the visit, but little variation occurred between control and treatment groups. However, on the post-survey an increase occurred in the response 'don't annoy animals' and this was most prevalent in the treatment group. Additionally, a slight decrease (4%) occurred in conservation-type response in the treatment group after the visit with children giving fewer conservation related responses like 'stop extinction.' However, the question was meant to evoke personal actions not broad conservation concepts, so this shift from conservation ideas to personal actions is not considered a negative result. There was also an increase in the post-suvey treatment group of children answering 'give animals enrichment'; while this is not the child-centred action that was aimed for, it indicates an increase in understanding from children in the treatment group that enrichment is beneficial for captive animals.

Over 70% of children responded that animals were the first thing that they thought of when they thought of the zoo or aquarium. There was very little change in this response from pre- to post-test or between control and treatment groups. This is contrast to Jensen (2014) who asked for five things you think of when you think of the zoo and reported a 34% increase in conservation-related thoughts from pre- to post visit. In fact, the current study showed a minor decrease (2%) in conservation related responses from pre- to post-survey. To produce more variation in response and perhaps ‘force’ more illuminating answers, it may have been better to ask the children to list several things, but in the trials this approach was not successful. Similarly, most children said that animals were the best part of the visit; however, slightly more children in the treatment group than the control group mentioned learning (4% vs 1%), enrichment (1% vs 0%) or the penguins and lemurs (29% vs 22%) specifically as the best part.

Even though outdoor learning has been shown to promote positive attitudes toward environmental education (Bennett, 2001), very little change took place from pre- to post-survey regarding favourite subject at school. It was predicted that an outdoor, science-based excursion, such as a trip to the zoo, may increase interest in science, and that subject interest at school was an objective way to measure it. However, the only change that occurred in STEM subject choice was a decrease of 2% in the treatment group listing STEM subjects as their favourite after the visit. While the EI was intended to be a fun activity, it is possible that some children were put off science by the use of words like hypothesis, experiment and enrichment. Or, the effect of the visit is not immediate, and that several weeks or months later a different result might occur (Balmford et al., 2007). Interestingly, more children in the treatment group (35%) responded that they ‘strongly agreed’ to enjoying learning about science after the visit than any other group, which suggests children may not be equating the science that they do in school, with the science that they experience outside the classroom. This could certainly be an area for further study. Also, it is possible that individual changes occurred in either a positive or negative direction, but here the descriptive analysis did not allow for individual results to be investigated.

5.4 General discussion

Zoos have been criticised for failing to provide evidence of a positive impact of their education programmes on visitors’ learning (Esson, 2009; Jensen, 2014). While previous studies have shown an increase in knowledge after a zoo or aquarium visit (Adelman et al., 2000; Tofield et al., 2003; Lindemann-Matthies and Kamer, 2006; Jensen, 2014), it has been more difficult to demonstrate improved attitude or positive conservation related behaviour change or actions to help the environment (Moss et al., 2015), especially in children. The current study demonstrates that learning, including pro-conservation behaviour change, does occur for children visiting a zoo or aquariums. One of the aims of the study was to enhance zoo-based learning through a purposefully developed educational intervention. Almost without exception, children in the treatment groups were more likely to show an increase in knowledge and behaviour and less likely to have a decrease than those in the control group.

Limitations did occur with the study. Very few DEIS schools visited either study site (anecdotally, staff report that the cost of the visit is prohibitive for these schools) and therefore the sample size of DEIS schools is low. Results did not find any effect of DEIS or non-DEIS on learning, but this may be due to the small sample that was studied. Again, few single gender schools participated in the study. Interestingly, a previous visit to a zoo or aquarium or enjoying nature shows had no significant effect on knowledge, attitude or behaviour scores. This is in contrast to the findings of other studies that state prior knowledge and experience effect learning outcomes (Adelman et al., 2000; Dierking et al., 2004; Falk et al., 2007). However, in reality almost all of the children had visited a zoo or aquarium before and it was difficult to develop a question which would adequately reveal children's concern for the environment. Perhaps watching nature shows does not indicate an overall pro-conservation attitude. Questions about pet ownership and recycling were considered but were dismissed as being more reflective of parents' beliefs than children's. It may have been better to phrase the behaviour questions 'I think visitors should be allowed to feed free-ranging animals' as 'It is okay for me to feed zoo animals' to make it personal, yet it was thought that some children may be reluctant to 'own up' to the action. The question 'I like to see animals with enrichment' was included in the behaviour section rather than the attitude section because the children in the treatment group made enrichment during the EI, and this was considered a positive pro-conservation action.

Informal science learning is shaped by many influences and can be difficult to measure. The current study, through rigorous research design and robust statistical analysis, offers evidence that learning does occur in the zoo and aquarium setting in Ireland. Maximum results were achieved when children participated in the EI and at Fota Wildlife Park, where animals are displayed in a naturalistic setting. The fact that participation in the EI, which included a supervised child-animal interaction session, led to increased learning is evidence that a limited and supervised interaction session with animals does benefit visitor learning in the zoo, something that other studies have alluded to, but not definitively shown (Anderson et al., 2003; Mun et al., 2013; Sherwen et al., 2015; Jones et al., 2016).

5.5 Conclusions

1. Knowledge scores were influenced by condition, site, location and school type. The most likely to show an increase in knowledge scores after a visit to the zoo or aquarium were treatment groups at Fota Wildlife Park.

2. Site and gender affected attitude scores, but not condition. Children at Fota were the most likely to have an improvement in attitude after a visit to the zoo. Girls had a slightly higher chance of increasing attitude scores than boys from pre- to post-test.

3. Condition, site and school type affected behaviour scores. Those most likely to have an increase in behaviour scores from pre- to post-survey were children at Fota Wildlife Park in a treatment group. Additionally, girls-only schools were more likely to have an increase in behaviour scores than mixed schools.

4. The qualitative question ‘how can you help zoo animals’ resulted in an increase in the answer not to tease/feed zoo animals in the treatment group and a general decrease in the answer ‘give them food’. There was little variation in response in the other qualitative questions from pre- to post-test.

5.6 References

Adelman, L. S., Falk, J. H. & James, S. (2000). Assessing the National Aquarium in Baltimore's impact on visitors' conservation knowledge, attitude and behaviour. *Curator,* 43(1), 33-61.

Ajzen, I. & Fishbein, M. (1980). *Understanding attitudes and predicting social behaviour*. Prentice-Hall: University of Michigan.

Anderson, U. S., Kelling, A. S., Pressley-Keough, R., Bloomsmith, M. A. & Maple, T. L. (2003). Enhancing the zoo visitor's experience by public animal training and oral interpretation at an otter exhibit. *Environment and behavior*, 35(6), 826-841.

Ballantyne, R., Fien, J. & Packer, J. (2001). School Environmental Education Programme Impacts upon Student and Family Learning: A case study analysis. *Environmental Education Research,* 7(1), 23-37.

Ballantyne, R. & Packer, J. (2002). Nature-based excursions: School students' perceptions of learning in natural environments. *International research in geographical and environmental education*, 11(3), 218-236.

Ballantyne, R., Packer, J., Hughes, K. & Dierking, L. (2007). Conservation learning in wildlife tourism settings: Lessons from research in zoos and aquariums. *Environmental Education Research*, *13*(3), 367-383.

Ballantyne, R., Packer, J. & Falk, J. (2011). Visitors' learning for environmental sustainability: Testing short-and long-term impacts of wildlife tourism experiences using structural equation modelling. *Tourism Management*, 32(6), 1243-1252.

Ballantyne, R., Packer, J. & Sutherland, L. A. (2011). Visitors' memories of wildlife tourism: Implications for the design of powerful interpretive experiences. *Tourism Management*, *32*(4), 770-779.

Ballantyne, R. & Uzzell, D. (1994). A checklist for the critical evaluation of informal environmental learning experiences. *International Journal of Environmental Education and Information*. 13(2), 111-124.

Balmford, A., Leader-Williams, N., Mace, G., Manica, A., Walter, O., West, C. & Zimmermand, A. (2007). Message received? Quantifying the impact of informal conservation education on adults visiting UK Zoos. *Catalysts for Conservation: a direction for zoos in the 21st Century*.

Bennett, J. (2001). Science with attitude: the perennial issue of pupils' responses to science. *School Science Review*. 82(300), 59-66.

Bexell, S. (2006). Effect of a Wildlife Conservation Camp Experience in China on Student Knowledge of Animals, Care, Propensity for Environmental Stewardship, and Compassionate Behavior Toward Animals. PhD Dissertation, Georgia State University.

Clarke, A. G. (2003). Factors affecting pool use by captive Humboldt penguins (*Spheniscus humboldti*). In *Proceedings of the 5th Annual Symposium on Zoo Research, Marwell Zoological Park, Winchester, UK, 7-8th July 2003.* (pp. 190-204). Federation of Zoological Gardens of Great Britain and Ireland.

Cohen, L. M., Manion, L. l. & Morrison, K. (2007). *Research methods in education, 6*. Routledge: London and New York.

Crawley, M. J. (2007). *The R book*. John Wiley & Sons Ltd., West Sussex, UK.

Davey, G., Henzi, P. & Higgins, L. (2005). The influence of environmental enrichment on Chinese visitor behavior. *Journal of applied animal welfare science*, *8*(2), 131-140.

Denzin, N. K. (1970). *The research act in sociology*. Aldine: Chicago, USA.

Dewey, J. (1998) [1933]. How we think: A restatement of the relation of reflective thinking to the educational process. Lexington, MA: Heath, 35, 64.

Dierking, L. D., Adelman, L. M., Ogden, J., Lehnhardt, K., Miller, L. & Mellen, J. D. (2004). Using a behavior change model to document the impact of visits to Disney's Animal Kingdom: A study investigating intended conservation action. *Curator: The Museum Journal*, 47(3), 322-343.

Dillon, J., Rickinson, M., Teamey, K., Morris, M., Choi, M. Y., Sanders, D. & Benefield, P. (2006). The value of outdoor learning: evidence from research in the UK and elsewhere. *School Science Review*, 87(320), 107.

Esson, M. (2009). Being in a hard place. BIAZA Research News 10, 1-3. http://www.biaza.org.uk/uploads/Research/ResearchNewsletter/Vol10. 2009.pdf. Date last accessed March 30, 2013.

Falk, J. H. & Balling, J. D. (1982). The Field Trip Milieu: Learning and Behaviour as a Function of Contextual Events. *Journal of Educational Research*, 76(1), 22–28.

Falk, J. H. & Dierking, L. D. (2000). *Learning from Museums: visitor experiences and the making of meaning*. Walnut Creek, CA. Alta Mira Press.

Falk, J. H., Reinhard, E. M., Vernon, C. L., Bronnenkant, K., Deans, N. L. & Heimlich, J. E. (2007). *Why zoos & aquariums matter: Assessing the impact of a visit to a zoo or aquarium*. Silver Spring, MD: Association of Zoos & Aquariums.

Falk, J. H., Heimlich, J. E., Vernon, C. L. & Bronnenkant, K. (2010). Critique of a critique: Do zoos and aquariums promote attitude change in visitors? *Society & Animals*, 18(4), 415-419.

Finlay, T., James, L. R. & Maple, T. L. (1988). People's perceptions of animals the influence of zoo environment. *Environment and Behavior*, 20(4), 508-528.

Hungerford, H. R. & Volk, T. L. (1990). Changing learner behavior through environmental education. *The Journal of Environmental Education*, 21(3), 8-22.

Jensen, E. (2011). *Learning about Animals, Science and Conservation at the Zoo: Large-scale survey- based evaluation of the educational impact of the ZSL London Zoo Formal Learning programme*. A report to The Zoological Society of London.

Jensen, E. (2014). Evaluating children's conservation biology learning at the zoo. *Conservation Biology*, 28(4), 1004-1011.

Jones, H., McGregor, P. K., Farmer, H. L. A. & Baker, K. R. (2016). The influence of visitor interaction on the behavior of captive crowned lemurs (*Eulemur coronatus*) and implications for welfare. *Zoo Biology*, 35(3), 222-227.

Krippendorff, K. (2004). *Content analysis: An introduction to its methodology*. Sage: Thousand Oaks, CA.

Lindemann-Matthies, P. & Kamer, T. (2006). The influence of an interactive educational approach on visitors' learning in a Swiss zoo. *Science Education*, 90(2), 296-315.

Lee, V. E. & Bryk, A. S. (1986). Effects of single-sex secondary schools on student achievement and attitudes. *Journal of Educational Psychology*, 78(5), 381.

Luebke, J. F., Watters, J. V., Packer, J., Miller, L. J. & Powell, D. M. (2016). Zoo Visitors' Affective Responses to Observing Animal Behaviors. *Visitor Studies*, 19(1), 60-76.

Mann, J. B., Ballantyne, R. & Packer, J. (2018). Penguin Promises: encouraging aquarium visitors to take conservation action. *Environmental Education Research*, *24*(6), 859-874.

Marino, L., Lilienfeld, S. O., Malamund, R., Nobis, N. & Broglio, R. (2010). Do zoos and aquariums promote attitude change in visitors? A critical evaluation of the American zoo and aquarium study. *Society & Animals*, 18, 126-138.

McPhee, M. E., Foster, J. S., Sevenich, M. & Saunders, C. D. (1998). Public perceptions of behavioral enrichment: Assumptions gone awry. *Zoo Biology*, 17, 525-534.

Moss, A. & Esson, M. (2010). Visitor interest in zoo animals and the implications for collection planning and zoo education programmes. *Zoo Biology*, 29(6), 715-731.

Moss, A. & Esson, M. (2013). The Educational Claims of Zoos: Where Do We Go from Here? *Zoo Biology*, 32, 13-18.

Moss, A., Jensen, E. & Gusset, M. (2015). Evaluating the contribution of zoos and aquariums to Aichi Biodiversity Target 1. *Conservation Biology*, 29(2), 537-544.

Mulcahy-O'Mahony, N. (2013). The development of a model of continuing professional development for teachers of primary science. PhD Thesis, University College Cork.

Mun, J. S. C., Kabilan, B., Alagappasamy, S. & Guha, B. (2013). Benefits of Naturalistic Free-Ranging Primate Displays and Implications for Increased Human–Primate Interactions. *Anthrozoös*, 26(1), 13-26.

Myers, O. E., Saunders, C. D. & Birjulin, A. A. (2004). Emotional dimensions of watching zoo animals: An experience sampling study building on insights from psychology. *Curator: The Museum Journal*, 47(3), 299-321.

Ogden, J. & Heimlich, J. E. (2009). Why focus on zoo and aquarium education? *Zoo Biology*, 28(5), 357–60.

Oppenheim, A. N. (1992). *Questionnaire design, interviewing and attitude measurement*. Pinter Publishers: London, UK.

Osborne, J., Simon, S. & Collins, S. (2003). Attitudes towards science: A review of the literature andits implications. *International Journal of Science Education, 25*(9), 1049–1079.

Palmberg, I. E. & Kuru, J. (2000). Outdoor Activities as a Basis for Environmental Responsibility. *The Journal of Environmental Education*, 31(4), 22–36.

Patrick, P. G. & Tunnicliffe, S. D. (2012). *Zoo talk*. Springer Science & Business Media.

Randler, C., Baumgärtner, S., Eisele, H. & Kienzle, W. (2007). Learning at workstations in the zoo: A controlled evaluation of cognitive and affective outcomes. *Visitor Studies*, 10(2), 205-216.

R Core Team (2017). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Rhoads, D. L. & Goldsworthy, R. J. (1979). The effects of zoo environments on public attitudes toward endangered wildlife. *International Journal of Environmental Studies*, 13(4), 283-287.

Roe, K., McConney, A. & Mansfield, C. F. (2014). The role of zoos in modern society: A comparison of zoos' reported priorities and what visitors believe they should be. *Anthrozoös*, 27(4), 529-541.

Sherwen, S. L., Hemsworth, P. H., Butler, K. L., Fanson, K. V. & Magrath, M. J. (2015). Impacts of visitor number on Kangaroos housed in free-range exhibits. *Zoo Biology*, 34(4), 287-295.

Smith, L., Broad, S. & Weiler, B. (2008). A closer examination of the impact of zoo visits on visitor behaviour. *Journal of Sustainable Tourism*, 16(5), 544-562.

Sommer, R. 1972. What do we learn at the zoo? *Natural History*, 81, 26-27. 84-85.

Tofield, S., Coll, R. K., Vyle, B. & Bolstad, R. (2003). Zoos as a source of free choice learning. *Research in Science & Technological Education*, 21(1), 67-99.

Tunnicliffe, S. D. (1998). Boy talk/girl talk: is it the same at animal exhibits? *International Journal of Science Education*, 20(7), 795-811.

Visscher, N. C., Snider, R. & Vander Stoep, G. (2009). Comparative analysis of knowledge gain between interpretive and fact-only presentations at an animal training session: an exploratory study. *Zoo Biology*, 28(5), 488-495.

Wagoner, B. & Jensen, E. (2010). Science learning at the zoo: Evaluating children's developing understanding of animals and their habitats. *Psychology & Society*, 3(1), 65-76.

Wellington, J. & Szczerbinski, M. (2007). *Research methods for the social sciences*. Continuum International Publishing Group: London and New York.

Whitehouse, J., Waller, B. M., Chanvin, M., Wallace, E. K., Schel, A. M., Peirce, K., Mitchell, H., Macri, A. & Slocombe, K. (2014). Evaluation of public engagement activities to promote science in a zoo environment. *PloS one*, *9*(11), p. e113395.

Wood, W. (1998) Interactions among environmental enrichment, viewing crowds, and zoo chimpanzees (*Pan troglodytes*). *Zoo Biology*,17, 211-230.

Chapter 5: Appendix

A1. Example letter of informed consent signed by each school before participating in the study.

Date

Consent Form

I, ………………………………, give permission for my class to participate in Courtney Collins's research study. This is an ongoing PhD project endorsed by UCC which has full approval of their Ethics Committee. Fota Wildlife Park and Dingle Aquarium also support the project.

The purpose of the study has been explained to me in writing. Participation is voluntary.

I understand that I can withdraw from the study, without repercussions, at any time, whether before it starts or while I am participating.

I understand that I can withdraw permission to use the data within two months of the survey, in which case the material will be deleted.

I understand that anonymity will be ensured in the write-up with individual identity never mentioned.

Signed……………………………………. Date……………….

Table A2. A description of the evolution of the survey instrument used in the research.

Name	Description	Input from
Phase 1	To gather preliminary information and to test the minimum age limit, a small group (4-5) of 9-year old boys answered questions about the study species in an informal setting in June 2013.	A group of children
Phase 2	The first version of the survey was trialed during a summer camp at Fota Wildlife Park in August of 2013, during this time several of the open ended questions were removed as time constraints were apparent, as well as, many children's reluctance to give written responses. It was also observed that staff were inclined to tell children the answers. Therefore an informal briefing for staff was introduced before administering the survey.	Fota education staff
Phase 3	The survey instrument was trialed in September of 2013 in a school setting this time with a 4^{th} class in County Cork. Again it was discovered that the students did not like to answer open-ended questions. For example, a question which gave the response option 'no/yes and if 'yes' please explain' was eliminated because the teacher reported that the children chose 'no' so that they would not have to write anything additional.	Dr Nunci O'Mahony - class teacher
Phase 4	The survey instrument was trialed again at a Fota camp in October of 2013. Subsequently, it was decided to reduce 'list three things that come to mind when thinking of Fota' question to 'list one thing'because most students only filled in one answer. Additionally, the order of the questions was modified. Previously 'how can you help zoo animals?' came at the end directly after the question about touching free-ranging lemurs, and there were many answers about not touching free-ranging animals. By putting that question at the beginning it was hoped to get more genuine answers with topics that students have not been previously been alerted to. There was no useable data from the October 2013 trial, but the surveys confirmed the answer categories, time to complete (about 20 min) and ease of understanding.	

Table A2 Continued. A description of the evolution of the survey instrument used in the research.

Name	Description	Input from
Phase 5	In order to simplify the survey (schools are unwilling to spend more than 10 – 15 minutes maximum on it) some questions were eliminated entirely and only one open ended question was included and one thought-listing question. Remaining questions are those that produced the most illuminating answers during the trials. For example, the question 'Why do you think some animals live in zoos?' was eliminated because the students showed a high level of knowledge already with most children answering with 'habitat loss' or 'so we can learn about them' and the question 'how can you help zoo animals?' remained as it is more unique, more personal and explores the main point of the research. At this time, the Heads of Education of both study sites approved the use of the survey.	Linda McSweeney-Walsh - Head of Education at Fota Maíre O'Shea - Head of Education at Dingle Aquarium
Phase 6	Last, the survey was reviewed by two experts in the field. One in UCC's Department of Applied Psychology as well as an education expert at Chester Zoo. Small changes were made, for example it was advised to add 'if you don't know the answer just take a guess' and to remove 'have you been to Fota Wildlife Park or Dingle Aquarium before' and ask generally about attendance at a zoo or aquarium. Also, one expert advised that more open ended questions would be better, however because of time constraints and previous feedback from students and teachers this was not possible.	Dr Marcin Sczcerbinski, UCC Applied Psychology Dept. Dr Andy Moss, Chester Zoo

Table A3. Results of Cohen's kappa for individual qualitative questions to measure inter-coder reliability

Question	kappa statistic	p value
1) Help zoo animals?	0.800	p < 0.001
2) Favorite subject?	0.933	p < 0.001
3) First thing?	0.925	p < 0.001
4) Best part?	0.862	p < 0.001

Questions are abbreviated, but are the same as those in Table 5.3. Cohen's kappa ranges from -1 (no agreement) to +1 (perfect agreement); N = 25 (randomly selected); For questions one and two, 25 pre-surveys were scored; for questions three and four, 25 post-surveys were scored.

Table A4. Variables originally included in model for knowledge

Independent Variables	Estimate	Standard error	t value	P - value
Condition	2.33065	0.18697	12.466	< 0.001*
Site	-2.00280	0.24541	-8.161	< 0.001*
Location	-0.90696	0.26996	-3.360	< 0.001*
Social	0.21144	0.45423	0.465	0.642
School type	0.96981	0.36552	2.653	0.008*
Gender	-0.12730	0.19604	-0.649	0.516
Zoo before	-0.13328	0.14148	-0.942	0.347
Nature shows	-0.05746	0.10424	-0.551	0.582

* Variables left in the model presented within the chapter are marked with an asterisk.

Table A5. Variables included in model for attitude

Independent Variables	Estimate	Standard error	t value	P - value
Condition	-0.01717	0.22713	-0.076	0.940
Site	-0.57402	0.29812	-1.925	0.055*
Location	0.14051	0.32795	0.428	0.669
Social	0.15750	0.55181	0.285	0.775
School type	-0.26188	0.44404	-0.590	0.556
Gender	0.42454	0.23816	1.783	0.075*
Zoo before	-0.19103	0.17187	-1.111	0.267
Nature shows	0.04555	0.12663	0.360	0.719

* Variables left in the model presented within the chapter are marked with an asterisk.

Table A6. Variables originally included in model for behaviour

Independent Variables	Estimate	Standard error	t value	P - value
Condition	0.4042122	0.1699311	2.379	0.018*
Site	-1.4274551	0.2230465	-6.400	< 0.001*
Location	-0.4212608	0.2453663	-1.717	0.087
Social	-0.0572003	0.4128479	-0.139	0.890
School type	0.7617346	0.3322203	2.293	0.022*
Gender	0.0009451	0.1781834	0.005	0.996
Zoo before	-0.2589771	0.1285902	-2.014	0.045
Nature shows TV	-0.1263291	0.0947428	-1.333	0.183

* Variables left in the model presented within the chapter are marked with an asterisk.

Chapter 6

Long-term learning in the zoo: quantifying the impact of zoological education in a week-long zoo camp and six months after an aquarium visit.

Abstract

There is increasing evidence that zoos and aquariums do, as intended, educate their visitors. However, even though most zoos offer a wide array of educational experiences, from brief tours to week-long programmes, few studies have considered how the duration of the educational experience may affect learning or if learning lasts. The current study followed the same methodology and statistical analysis described in Chapter 5 but had two additional purposes. First, the impact of a five-day summer camp experience on children's learning was investigated and compared to the one-day experience. Similar to the one-day experience, learning was positively affected by participation in the educational intervention, but also by previous experience at Fota Wildlife Park. Children who had not attended a camp at Fota before were more likely to experience an increase in attitude and behaviour score than children who had previously attended a camp. Initially, camp children scored higher in knowledge and behaviour than school tour children, but after the visit school tour children were more likely to have increases in knowledge, whereas camp children were more likely to have increases in behaviour scores. Second, learning retention was investigated six months after a school tour at Dingle Aquarium. Children in the treatment group had a higher total group score than children in the control group in both post-survey and the retention test. However, children in the control group were more likely than those in the treatment group to experience increases in both knowledge and behaviour on the retention test. Girls were also more likely than boys to have an increase in their behaviour scores on the retention test. Attitude was largely unaffected in either study at Fota Wildlife Park or Dingle Aquarium. The studies show that learning did occur in the zoo setting and that it persists, but education could be enhanced with longer programmes.

6.1 Introduction

Zoos and aquariums define themselves as centres for education (Patrick et al., 2007; Roe et al., 2014), and recent research confirms that many children do learn as a result of a trip to a zoo or aquarium (Jensen, 2014; Chapter 5 of this thesis), particularly when accompanied by a purposefully-designed educational intervention (Randler et al., 2007; Chapter 5 of this thesis). However, few studies have investigated if the duration of the educational experience affects learning. Furthermore, little attention has been given to the long-term impact of zoological education, even though, if learning is transient, the purpose of the visit may be questioned.

Intuitively, it seems that a longer experience should produce more in-depth and perhaps longer lasting learning, but rarely has this been tested. Previous research has found that children in five-day environmental education programmes had a less negative attitude towards the environment and specific species (Emmons, 1997), and were more willing to take action to help the environment (Mittelstaedt et al., 1999) at the end of the programme than at the beginning. More recently, Bexell et al. (2013) evaluated five-day long camps in China, which aimed to inspire children to develop a caring attitude towards animals and the environment. At the end of camp, the children (8-12 years) showed significant increases in knowledge, inclination for action to help the environment and empathy towards animals. Importantly, the campers' actual behaviour was recorded, and over the course of the week negative behaviour declined (Bexell et al., 2013). However, these authors did not compare their results to a shorter learning experience, so it is not possible to determine if the duration of the education programmes was one of the contributing factors in the changes that were discovered. Bogner (1998) did compare the success of one-day and five-day long ecology programmes at increasing pro-environmental behaviour. The results revealed that students in both of the programmes had increases in knowledge gain, but it was the children in the five-day programme that developed positive shifts in actual and intended behaviour, such as taking action to help the environment. The author concluded that, if the programme is of sufficient length, students' behaviour towards the environment can be influenced by education.

However, programme duration may not be relevant if learning after the experiences is not retained. Yet, learning retention after informal science experiences is an under-studied area, even though the demonstration of a lasting effect is potentially the most important goal for environmental educators (Leeming et al., 1993). Because of the general lack of research surrounding pro-environmental educational, even fewer studies have assessed organisations' long-term impact on learning (Kuhar et al., 2010). However, limited research does indicate that learning persists months or even years after an educational experience. Farmer et al. (2007) found that one year after an environmental education field-trip, students still remembered what they had learned, with some students describing experiments in detail; there was also evidence of retention of pro-environmental attitudes in several students. Additionally, knowledge was retained in students (aged 7-12 years) two years after attendance at an environmental education programme for schools outside the Kalinzu Forest Reserve, Uganda (Kuhar et al., 2010). Previously, Kuhar et al. (2007) determined that their programme was successful at increasing short-term knowledge gain. Students were then retested one and two years later, and it was found that knowledge had increased above the initial pre-programme level (Kuhar et al., 2010). However, the authors cautioned that knowledge gain is only the first step in a long process, which should culminate in a positive environmental impact. Ballantyne, Packer & Falk (2011) investigated the short- and long-term impact of wildlife tourism experiences on visitors' awareness, appreciation and commitment to actions on environmental issues. The authors report that visitors' pre-visit commitment to the environment and motivation to learn were the best predictors of long-term learning impact.

More recently, a study investigated visitors' learning two years after a zoo or aquarium visit (Jensen et al., 2017). Similar to Kuhar et al. (2010) and the current study, Jensen et al. (2017) built on results from a previous study (Moss et al., 2015). The latter authors discovered that an understanding of biodiversity and knowledge of actions to help protect biodiversity significantly increased after a zoo or aquarium visit. In their follow-up study, two years later, results from 161 respondents revealed that biodiversity understanding remained unchanged, from the post-survey immediately after the visit, to the retention test two years later. However, knowledge of actions to help protect biodiversity improved from the post-survey to the retention test. The authors concluded that this could be due to the visitors' heightened awareness of biodiversity after their zoo visit. In other words, as a result of their zoo experience, visitors paid more attention to subsequent biodiversity messages that they encountered in their daily lives (Jensen et al., 2017). There is also evidence that it is not only knowledge, but also behaviour that lasts beyond the zoo visit. Mann et al. (2018) found that over a year after a visit to an aquarium approximately 50% of adult visitors, who participated in a study during which they made a promise to penguins to become more environmentally responsible, were still carrying out their intended actions, such as not littering.

In contrast, Adelman et al. (2000) discovered actions to help the environment learned during an aquarium visit were not retained. Adelman et al. (2000) conducted follow-up telephone interviews with 48 visitors, 6-8 weeks after a visit to the National Aquarium in Baltimore and discovered that visitors were likely to mention conservation and preserving the environment when discussing their visit. Visitors were also more likely to mention biodiversity, and the interconnections between humans and animals 6-8 weeks later than immediately after the visit (Adelman et al., 2000). Yet, the authors concluded that while the visit may have initially inspired visitors towards conservation action, the fact that visitors did not use action words to express their attitude towards conservation 6-8 weeks later (or they had returned to pre-visit level) indicated that the impact of the visit did not lead to long-term conservation actions. However, the relatively short time between the initial visit and the follow-up interview suggests that it may take visitors a longer time to assimilate what they learned, perhaps in combination with other reinforcing experiences. The fact that visitors were more likely to mention biodiversity during the follow-up call, rather than immediately after the visit, could indicate that they were beginning to process what they had learned at the aquarium. Ballantyne, Packer & Falk (2011) also reported a low level of long-term impact on visitors' learning after participation in a wildlife tourism experience, but attitude and behaviour were particularly low four months later. However, this could be enhanced by facilitating emotional connections with animals and reflection during the visit (Ballantyne, Packer & Sutherland, 2011).

Zoos and aquariums aspire and are expected to be leaders in environmental education (Ogden and Heimlich, 2009; Roe et al., 2014), but there is little understanding of how programme duration affects learning or of the long-term effect of zoological education on visitors' knowledge, attitude and behaviour. If the education that zoos and aquariums provide, even if successful in the short-term, does not have lasting benefits, then their goals of promoting positive pro-environmental behaviour and actions may not be realised. The current chapter builds on the results of the previous chapter, by considering if a longer duration camp at Fota Wildlife Park enhances learning, and by evaluating knowledge, attitude and behaviour six months post-visit at Dingle Aquarium.

The specific aims of the research were:

1) To evaluate the effect of a five-day long programme on children's knowledge, attitude and behaviour at Fota Wildlife Park.

2) To compare pre-survey scores of school tour students with those of camp children at Fota Wildlife Park, and to compare the difference between pre- and post-survey scores for treatment groups participating in school tours and camps.

3) To investigate changes in knowledge, attitude and behaviour six months after a visit to Dingle Aquarium.

6.2 Methodology

The study sites, survey instrument and the educational intervention are the same as those described in Chapter 5.

6.2.1 Fota Wildlife Park camps

Procedure

Fota Wildlife Park offers children the opportunity to participate in camps throughout the year. This provided the opportunity to investigate the effects of a five-day long educational experience on children's learning. The camps at Fota are part of the education programme, generally taught by the same staff that conduct the school tours, and at the time of the study were offered during Halloween, Easter, July and August. The camp costs €115 per child for the week (Fota Wildlife Park, 2018). The camp curriculum included: a tour of Fota, conservation-based art and sport activities, games, movies, ecology and conservation activities. Generally, all camps followed the same standard curriculum; however, some variation of the programme was unavoidable. For example, sometimes a science show occurred; this has been included as an independent variable (Table 6.2). Age range is the same at described in Chapter 5. All children of the correct age to attend a camp were asked to participate in the research, and there was almost complete agreement to this. However, some non-English speakers were unable to complete the survey, which was then excluded from the study.

The procedure closely followed that described in Chapter 5. During the camp, the children completed the pre-survey on Monday morning in a classroom-like setting, after arriving at Fota, but before any activities occurred, followed by a tour of the park. They completed the post-survey on Friday afternoon at lunchtime. The educational intervention (EI) for treatment groups was conducted on Wednesday. The EI was the same as previously described (see Chapter 5) and included information on both the penguins and the lemurs. Children in the treatment group had an additional tour of Fota on Friday morning, when they saw the animals interacting with the enrichment that they had prepared. Initially, it was decided to randomly assign some children as control and some as treatment. However, during a trial this proved to be logistically difficult. Therefore, it was decided that an entire camp would be designated as control or treatment (Table 6.1). Generally, every second camp was assigned as a treatment group and then the following year this was reversed. However, there was concern from management that parents might complain if their child attended the camps often and became bored of the EI. Therefore, at times the designation of a camp as treatment or control had to be changed. Children did not know that they would be participating in a research programme before the camp. The wording of the survey was changed slightly to reflect a camp experience (see Appendix 3, surveys 5 and 6) rather than a school tour. Only the data from children who participated in the entire camp and completed both the pre- and the post-survey were included in the study. This yielded a study sample of 110 matched-pairs surveys over the course of the study between October, 2013 and August, 2016.

Table 6.1. Details of the composition of camp groups that completed the survey at Fota Wildlife Park between 2013 and 2016.

Camp ID	Gender	Age	No of Children in group	Condition
FC131*	Boys	9-10	5	Control
FC141	Mix	9-10	8	Treatment
FC142	Mix	10-12	18	Treatment
FC143	Mix	9-12	14	Control
FC144	Boys	11	3	Treatment
FC151	Girls	9-10	2	Control
FC152	Mix	10-12	11	Control
FC153	Mix	10-12	13	Treatment
FC154	Girls	9-12	4	Control
FC161	Girls	9-12	2	Treatment
FC162	Mix	9-12	16	Control
FC163	Mix	9-12	14	Treatment

*This group did not answer questions about the penguins on the survey

Data analysis

In this chapter, because there are several different sections with many results, a discussion is incorporated into each section of the results, followed by a general discussion. Since Chapter 5 already clarified intricacies of the survey and children's learning, it was not considered necessary to analyse responses to individual questions in the current chapter. Therefore, for the data collected at the Fota Wildlife Park camp, the mean group score for each section of the survey (knowledge, attitude and behaviour) is presented for treatment and control groups. This was not investigated further with inferential statistics because where possible this research is primarily interested in individual learning patterns during an educational experience. The camp survey data were analysed using general linear models (following the same technique described in Chapter 5), where the difference in pre- and post-scores was used as the dependent variable for each section: knowledge, attitude and behaviour to test whether a camp experience impacted children's learning. Independent variables included in the models are listed in Table 6.2. Descriptive statistics were used to explore children's responses to the question 'how can you help zoo animals?' This is the only qualitative question that was included, because results from Chapter 5 indicated little variation in response to other qualitative questions.

Since self-selected groups of visitors, such as camp children, may have higher than expected conservation knowledge before the visit (Mittelstaedt et al., 1999; Adelman et al., 2000), the study compared the results of school tour versus camp children as a group. The Mann-Whitney U test was used 1) to determine if children began the camp and the school tour with the same level of knowledge, attitude and behaviour by analysing their pre-survey group scores and 2) to identify any differences in school and camp children's knowledge, attitude and behaviour scores between pre- and post-survey for those that received the EI.

Table 6.2. The independent variables included in the models for camp data at Fota Wildlife Park.

Independent variables included in the model	Response options	Demographics known or self-reported on survey
Condition	Control/Treatment	Known
Attended science show	No/Yes	Known
Gender	Male/Female	Self-reported
Previously attended a camp	No/I'm not sure/Yes	Self-reported
Previously visited a zoo	No/I'm not sure/Yes	Self-reported
Enjoy watching nature shows on TV	No/I'm not sure/Yes	Self-reported

6.2.2 Dingle Aquarium follow-up study

Chapter 5 of this thesis confirms that learning occurred after children visited Dingle Aquarium. However, in certain areas, such as attitude, learning was limited. One of the possibilities for this was that the period between the educational experience and the post-survey, administered directly after the visit, did not allow for attitudes to fully develop (Bogner, 1998). At Dingle Aquarium, when there was a unique opportunity to return to one school and re-administer the survey six months after children visited the aquarium, it was decided to avail of this opportunity.

Procedure

The school involved in the follow-up study is listed in Chapter 5, Table 5.2 as school 4 and 6 and the involved groups were: DS151, DS152, DS161 and DS162. The school's pre- and post-survey data are included in Chapter 5. The school was chosen because when the children originally participated in the study they were in 5th class, which meant six months later they were still attending the same school but were now in 6th class. Furthermore, they remained in their original class groups which were designated as control or treatment. The school brought their fifth class to the aquarium every year, which meant that two classes (2015 and 2016) participated in the follow-up study, which yielded a sample size of 91 students. For the follow-up study, the researcher returned to the school six months after the Dingle Aquarium visit to administer the survey for a third time (Appendix 3, survey 7). The data that were collected in the six-month follow-up or the second post administration of the survey are referred to as the post-2-survey or the retention test. The children did not know that they would be tested for a third time. Only data from participants who completed all three surveys were included in this part of the study.

To clarify, surveys were designated as:

1) Pre-survey, the survey which was administered before the visit to Dingle Aquarium;

2) Post-survey, the survey which was administered directly after the visit to Dingle Aquarium;

3) Post-2-survey, the survey which was administered six months after the visit to Dingle Aquarium.

Jensen et al. (2017) raised the concern that those individuals who agree to participate in a retention test might be more attuned to biodiversity related issues and therefore bias the results. However, in the current study this was not an issue because, while no student was forced to complete the survey, the school teacher agreed that the children would participate in the follow-up test. The alternative for the student was to sit and wait for the rest of the class to complete the test, which was not an appealing option to the students and there was almost complete agreement to the follow-up survey.

Data analysis

For the data collected at Dingle Aquarium, first a Friedman test was used to evaluate differences in mean test scores (pre-, post- and post-2) for both control and treatment groups. Bar charts show the mean group score for individual sections of the survey (knowledge, attitude and behaviour) for control and treatment groups. Then, general linear models (following the same technique described in Chapter 5) were used to test which variables might impact long-term learning. The difference in total score for each section: knowledge, attitude and behaviour, between post-survey and post-2-survey was used to evaluate changes in learning over six months. Independent variables included in the models were condition (control/treatment), gender (male/female), visited an aquarium before the study (no/I'm not sure/yes), enjoy nature shows on TV (no/I'm not sure/yes). The question 'how can you help zoo animals?' was explored as described above.

6.3 Results and discussion

6.3.1 Fota Wildlife Park - Camp data

Mean group scores for each section of the survey indicated that both groups had increases in knowledge, attitude and behaviour between pre- and post-surveys, but the treatment group had slightly larger increases for knowledge and behaviour (Table 6.3).

Table 6.3. The mean group score for each section of the survey conducted at the camps at Fota Wildlife Park.

Knowledge	Control group	Treatment group
PRE	0.72	0.77
POST	0.79	0.90
Attitude		
PRE	0.77	0.75
POST	0.80	0.79
Behaviour		
PRE	0.79	0.82
POST	0.87	0.93

General linear model: Knowledge

The general linear model for knowledge showed that only condition (control or treatment) had a significant effect on knowledge score (p=0.001) (Figure 6.1) (see Appendix, Table A1 of this chapter for complete model). Children in the treatment group (76%) were significantly more likely than those in the control group (48%) to have an increase in knowledge at the end of the camp (Figure 6.1). Only 2% of campers in the treatment group had a decrease in knowledge at the end of the week versus 12% in the control group (Figure 6.1).

This finding is not surprising, considering that the educational intervention (EI) was the same as described in Chapter 5, where similar results were discovered. Although the camp children were at Fota for five days and experienced a broad conservation curriculum, slightly less than half of the children in the control group demonstrated an increase in knowledge gain on the survey. In contrast, just over three quarters of children in the treatment group showed an increase in knowledge at the end of the week. Participation in the educational intervention was the most significant predictor for knowledge gain in children attending a camp at Fota Wildlife Park. Borchers et al. (2014) also reported significant increases in knowledge in children enrolled in a long-term, specially developed environmental education programme compared to children who did not attend the programme. Of course, it is possible that in the present study the children in the control group gained knowledge in other areas that were not included on the survey. However, the survey was designed based on the standard Fota Wildlife Park curriculum and should have been easily answered by either group. Additionally, if an educational programme is successful at eliciting long-term learning, having attended a camp before should result in a higher level of knowledge (Lukas and Ross, 2005; Ballantyne, Packer & Falk, 2011); however, this was not discovered here.

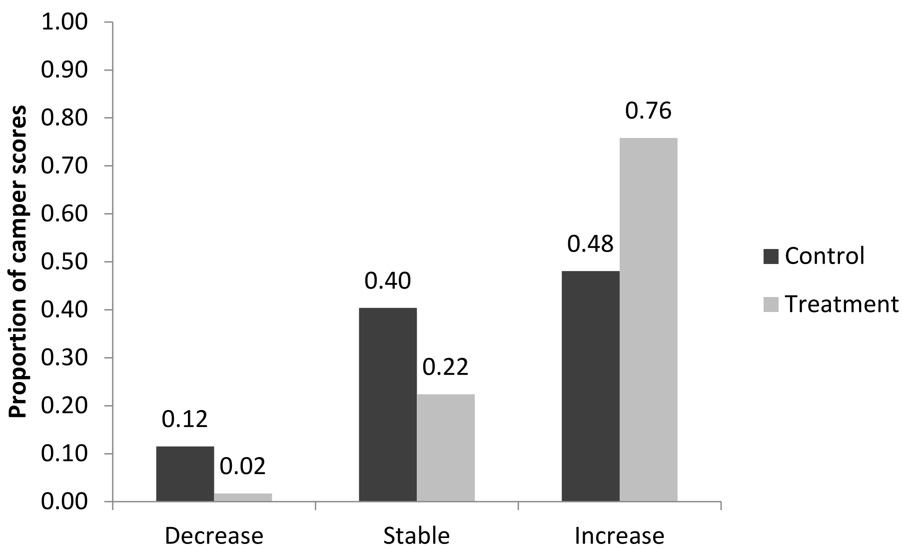


Figure 6.1. The proportion of campers whose knowledge scores decreased, remained stable or increased for control and treatment groups between pre- and post-survey.

General linear model: Attitude

The general linear model for attitude showed that having attended a camp before had a significant effect on attitude score (p=0.034) (Figure 6.2) (see Appendix, Table A2 of this chapter for the complete model). Children who had not previously attended a camp were more likely to have an increase in attitude score (61%) than those who had previously been to a camp (45%) (Figure 6.2). More than double the proportion of respondents who had been to a camp before (29%) had a decreased attitude score compared to those who had not (12%) (Figure 6.2).

Prior experience at Fota did not enhance these children's attitude, which is surprising given that reinforcing experiences are thought to benefit learning (Adelman et al., 2000). The reason for this result is not clear. It is possible that the children who had previously attended a camp had higher expectations for the activities. This may have led to disappointment and a decrease in attitude, if what they experienced did not equal what they expected. Or perhaps these children had previously been introduced to concepts like conservation, biodiversity and animal welfare, and they thought more critically about the questions that were asked on the survey, which could also have resulted in lower attitude scores. Still, both groups did experience increases in attitude score. This is similar to the results reported by Mittelstaedt et al. (1999) that even though children arrived at an outdoor environmental education camp with a positive attitude toward the environment, they had an even stronger positive attitude at the end of the camp. However, in the present study 29% of children who had attended a camp before had a decrease in attitude at the end of the educational experience. Children in the pilot study at Fota were disinclined to answer open-ended questions; however, these results indicate that it would be appropriate for future studies to follow-up the attitudinal questions with 'why,' which would facilitate disentangling the results.

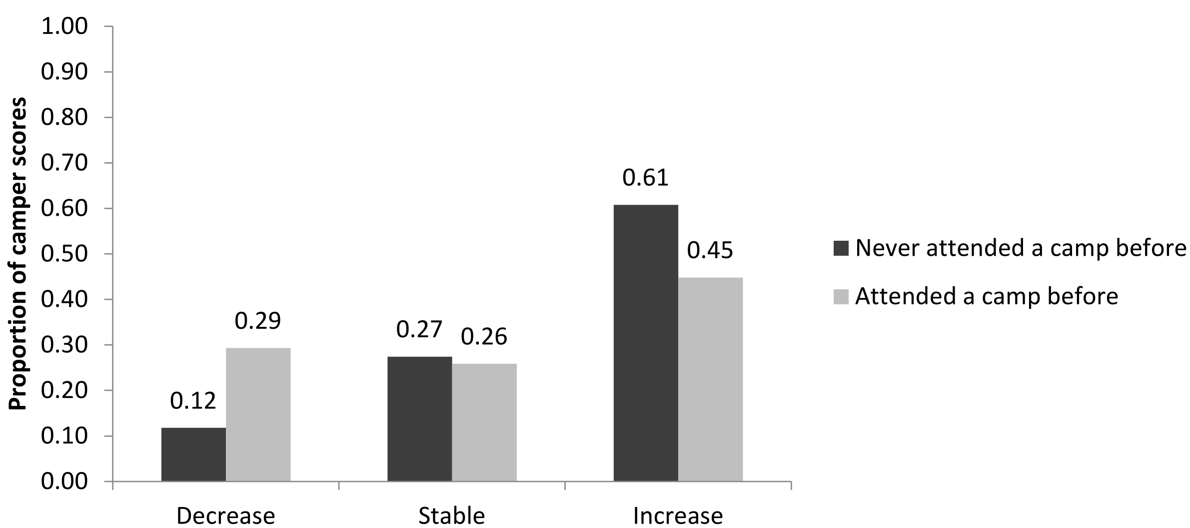


Figure 6.2. The proportion of campers whose attitude scores decreased, remained stable or increased for those who had or had not attended a camp before between pre- and post-survey.

General linear model: Behaviour

The general linear model for behaviour revealed that condition (p=0.027) (Figure 6.3) and attending a camp before (p=0.002) (Figure 6.4) had a significant effect on behaviour score (see Appendix, Table A3 of this chapter for the complete model). None of the respondents in the treatment group showed a decrease in their behaviour score from pre- to post-survey compared to 15% in the control group (Figure 6.3). Children who had never attended a camp at Fota Wildlife Park before showed an 80% increased behaviour score compared to only 52% of those who had attended a camp before (Figure 6.4).

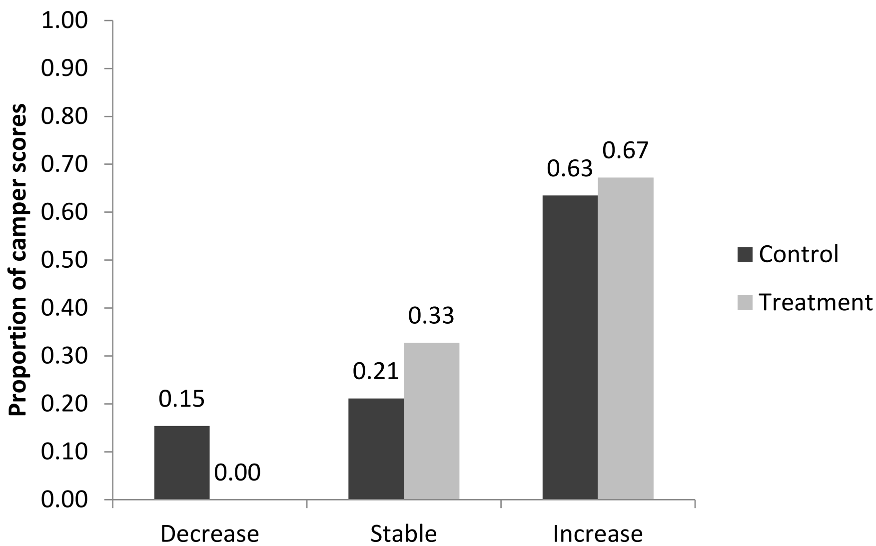


Figure 6.3. The proportion of campers whose behaviour scores decreased, remained stable or increased for control and treatment groups between pre- and post-survey.

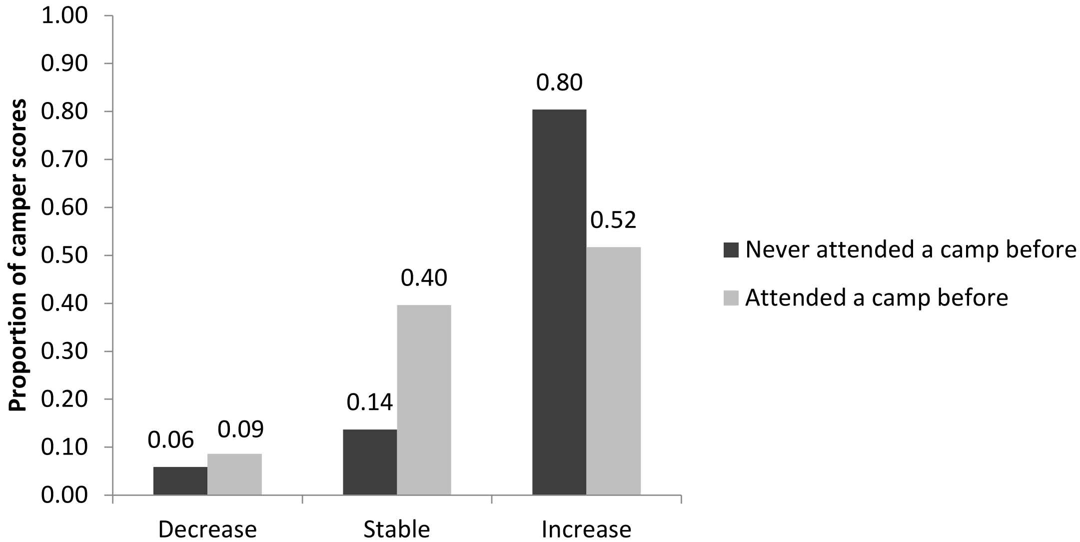


Figure 6.4. The proportion of campers whose behaviour scores decreased, remained stable or increased for those who had or had not attended a camp before between pre- and post-survey.

Since the ultimate goal of environmental education is pro-environmental behaviour change (Ogden and Heimlich, 2009), these results are encouraging and suggest that a longer duration programme is beneficial at promoting positive behaviour change, especially for the treatment group. Bogner (1998) and Bexell et al. (2013) report similar findings after a week-long camp experience. At the Chinese camps, negative behaviours (e.g. picking flowers) began to decrease after the third day of camp, indicating that the duration of the programme does influence behaviour (Bexell et al., 2013). Probably for similar reasons as the attitude scores, children who had not attended a camp at Fota Wildlife Park before were more likely to have an increase in their behaviour score at the end of the five-days compared to those who had, though both groups had a low probability of decreases in behaviour.

Qualitative question: Control group

There was little difference between pre- and post-response for the question ‘how can you help zoo animals?’ for the control group. Most children answered the qualitative question with the general response of ‘take care of animals’ on both the pre- (20%) and post-survey (22%) (Figure 6.5). The largest shift in response from pre- (16%) to post-survey (20%) occurred with the response ‘don’t annoy animals’ and ‘other’, which is difficult to interpret since responses did not fit easily into any category (Figure 6.5). Although children in the control group were not specifically told ‘don’t annoy the animals’, some still picked up on this educational message during the week perhaps from signage or passing comments by staff. Encouragingly, there were several conservation-related ideas (stop deforestation) and child-centred ideas (adopt an animal), which could suggest a sense of self-empowerment vital to environmental education (Hungerford and Volk, 1990), but since there was almost no change from pre- to post-survey it is likely that the children arrived at Fota with these ideas and they are not attributable to the camp curriculum.

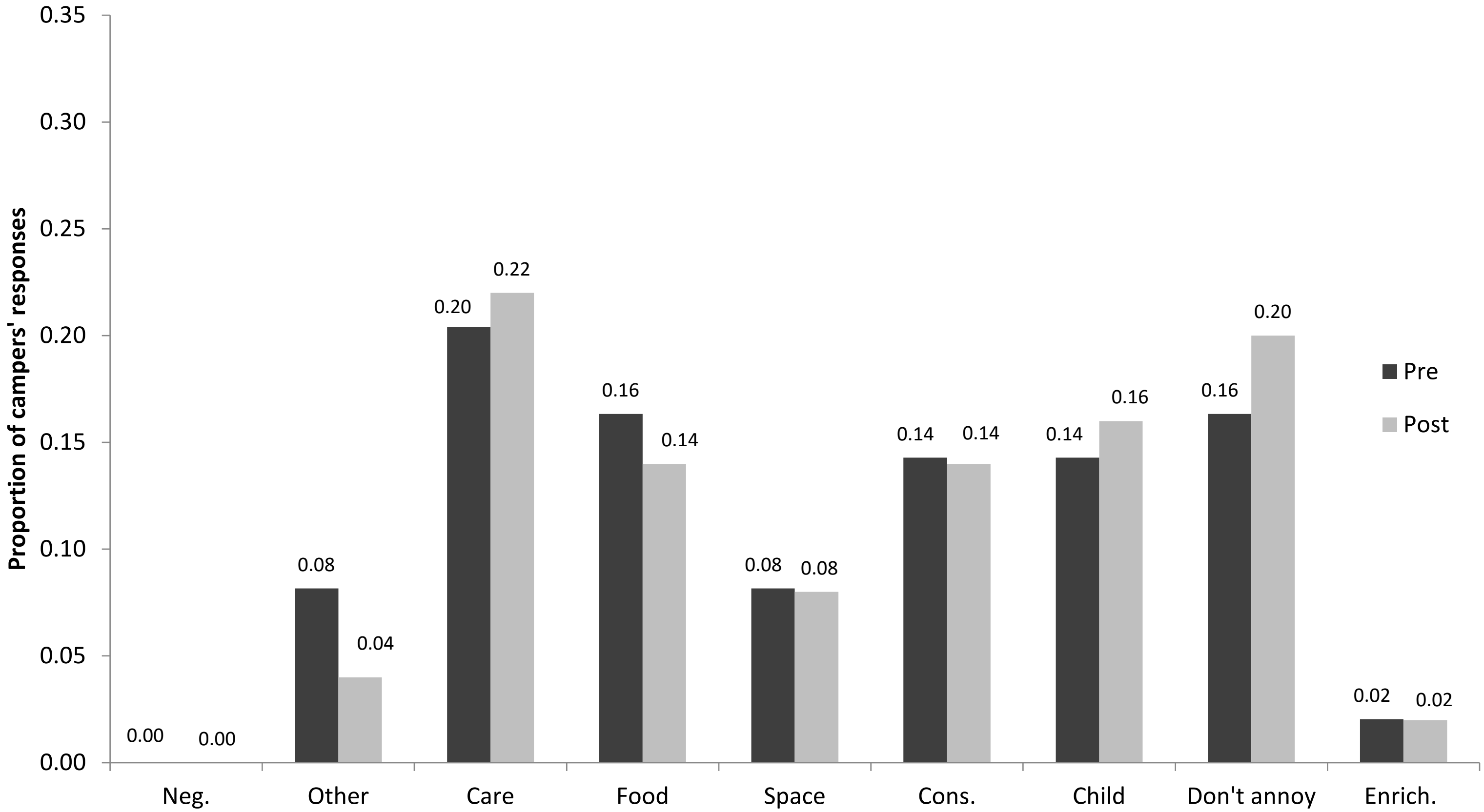


Figure 6.5. Student responses in the control group for the question 'how can you help zoo animals?' on the pre- and post-survey.

Qualitative question: Treatment group

The treatment camp group showed greater variation in response to the qualitative question than the control group. On the pre-survey, the majority of children in the treatment group (29%) gave a child-centred response to the questions, such as ‘adopt an animal’. This decreased on the post-survey, but there were increases in children answering ‘don’t annoy animals’ (16% vs 27%) and in children responding to ‘give animals enrichment’ (2% vs 24%). Additionally, there were decreases from pre- to post-survey in ‘care for animals’ (18% vs 9%) and ‘give them space’ (18% vs 5%) (Figure 6.6). This positive result indicates a change from general, non-specific actions to positive, specific actions in children or recognition that enrichment is beneficial to animals.

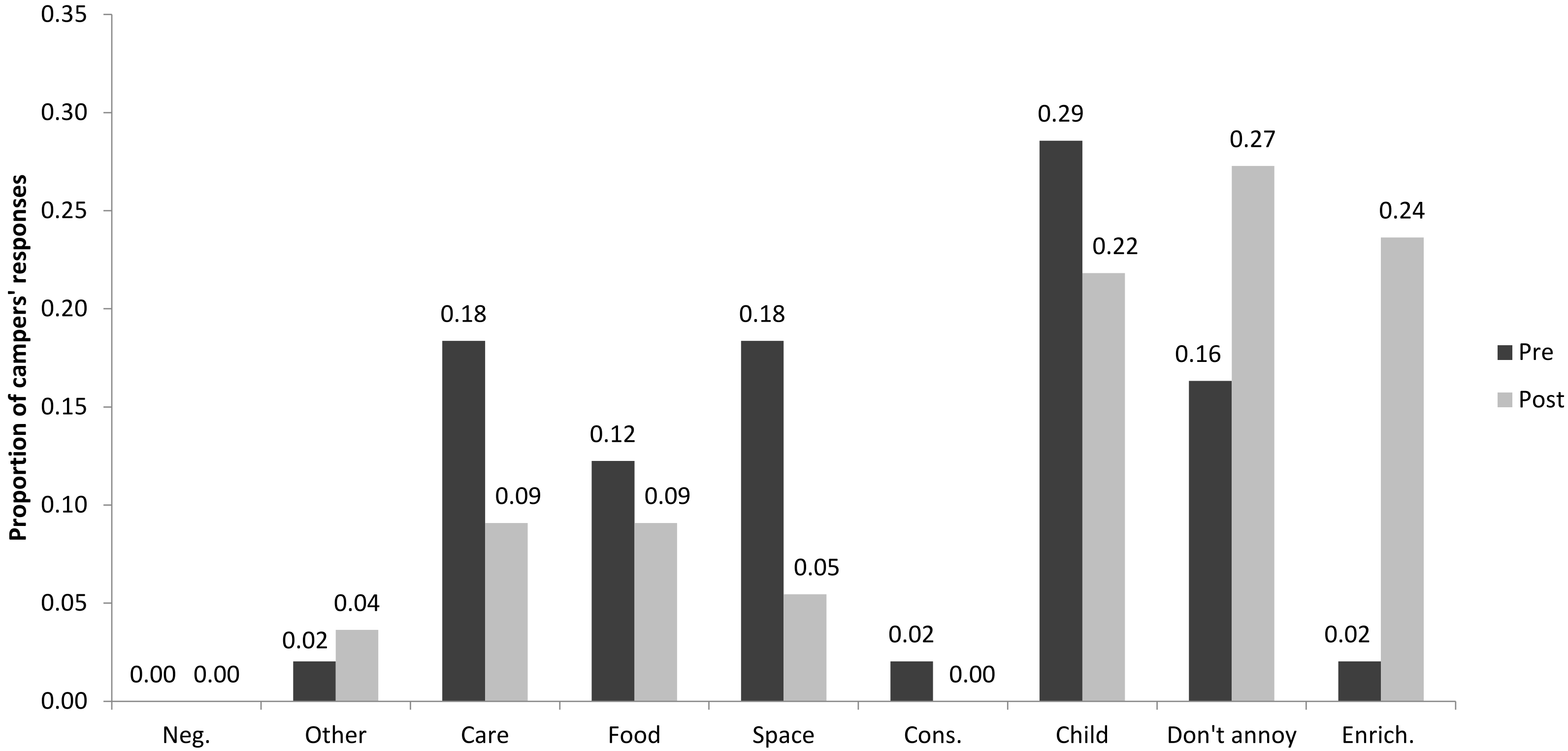


Figure 6.6. Student responses in the treatment group for the question ‘how can you help zoo animals?’ on the pre- and post-survey

6.3.2 Educational impact at Fota Wildlife Park - school tour vs camp

First, the difference in pre-survey scores (knowledge, attitude and behaviour) between all school tour students and camp children was investigated with the Mann-Whitney U test (Table 6.4). Children attending camps had a higher mean test score than children attending a one-day school tour on the pre-survey for knowledge, attitude and behaviour, with statistically significant differences occurring for knowledge (9.31 vs 13.53) and behaviour (9.56 vs 10.84) (Table 6.4). Visitors who choose to attend a specific education programme may already have a high level of knowledge (Adelman et al., 2000), and the results found here support that. This assumes that children chose to attend a five-day long camp at Fota because of an active interest in conservation and the environment, while school tour children attended because their teacher chose it for them, though of course some of them may also have an interest in conservation.

Table 6.4. The result of the Mann-Whitney U test for pre-scores between school tour children and camp children.

	Mann-Whitney U	**Mean**		**P - value**
		School	Camp	
Knowledge	14826	9.31	13.53	$p < 0.001$
Attitude	9261	14.56	14.91	$p = 0.172$
Behaviour	10720	9.56	10.84	$p < 0.001$

Knowledge

For the post-visit data, the Mann-Whitney U test showed that there was a statistically significant difference in the knowledge scores between school and camp treatment groups (W=5971.5, p=0.001). More children on a one-day school tour (88%) had an increase in knowledge compared to children attending a camp (76%) (Figure 6.7). However, school tour children were also slightly more likely than camp children (4% vs 2%) to have a decrease in knowledge (Figure 6.7). There was a higher number of camp children compared to school tour students (22% vs 8%) whose knowledge level remained stable

(Figure 6.7). Since camp children had a higher knowledge level to begin with, increasing it could have been more difficult.

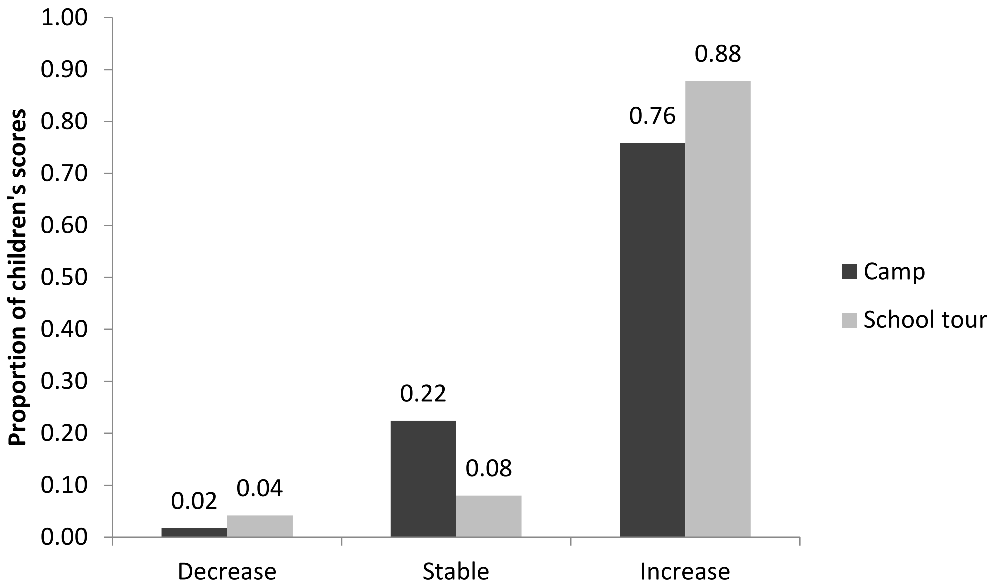


Figure 6.7. The proportion of campers versus school tour children in treatment groups whose knowledge scores decreased, remained stable or increased between pre- and post-survey.

Attitude

There was no difference in attitude scores detected between pre- and post-visit tests for school tour students and camp children (W=9163, p=0.22). Nature-based trips of just several hours have previously been reported to enhance students' attitude toward the environment (Ballantyne and Packer, 2002), which suggests that a longer progamme would have a more profound impact; however, in the current study no difference in learning outcomes was detected between the one-day or five-day experience at Fota Wildlife Park for children's attitude.

Behaviour

A significant difference occurred in behaviour scores between camp children and school groups between pre- and post-visit tests (W=10303, p=0.003). A higher proportion of children in the camp group (67%) had an increase in their behaviour score compared to 51% of school tour students (Figure 6.8). Also, most importantly camp children showed no decrease in behaviour score, but school children showed a large decrease (17%) in behaviour score between pre- and post-test (Figure 6.8). These results apply to children participating in a treatment group only, but again suggest that the week-long programme reinforced pro-conservation behaviours. This echoes the results of Bogner (1998), who reported improved behaviour at the end of a week-long experience, but not a one-day programme.

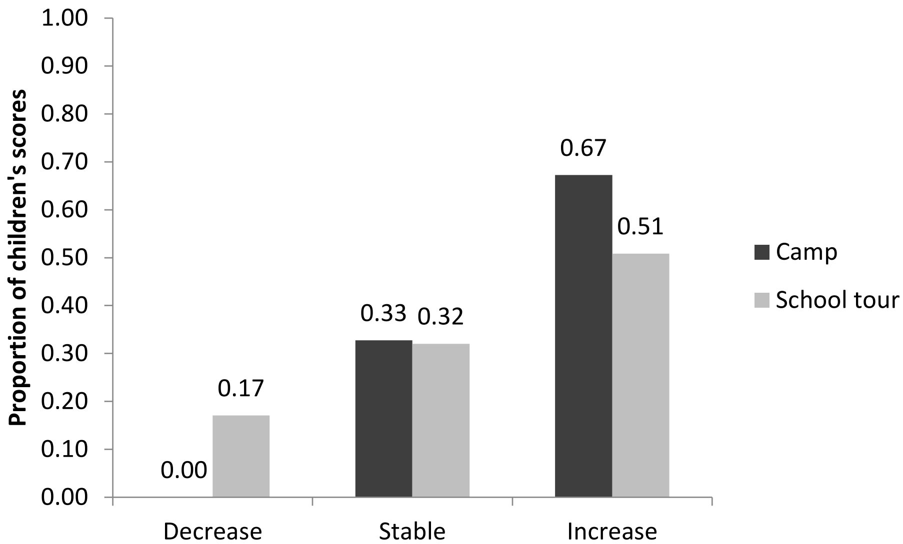


Figure 6.8. The proportion of campers versus school tour children at Fota in treatment groups whose behaviour scores decreased, remained stable or increased between pre- and post-survey.

Qualitative question

A comparison of the one-day school tour students’ (see Chapter 5) and the five-day camp children’s (this chapter) responses to the qualitative question generally revealed deeper understanding for the camp children. The school tour treatment group’s most common choice on the post-survey was ‘don’t annoy animals’ (24%), however ‘caring for them’, ‘giving them food’ and ‘space’ were still popular choices (see Chapter 5, Table 5.10). There was a larger decrease in this type of general, non-specific action answer for the camp treatment group on the post-survey (Figure 6.6). Additionally, during the one-day experience, few children in the treatment group, responded to ‘give animals enrichment’ on the post survey (9%) (see Chapter 5, Table 5.10) compared to 24% of campers in the treatment group (Figure 6.6). The five-day experience may have been the ideal duration to reinforce the concept of enrichment, which was new to most children, and allow for the development of a deeper understanding of the needs of captive animals.

The large variation in response between the school tours and camps, and also between the control and treatment camp groups, suggest a greater depth of understanding and a heightened sense of self-empowerment in children attending a five-day camp, particularly those who experienced the educational intervention. This shift in response follows the goals of the Tbilisi Declaration (UNESCO, 1978), which includes the development of new pro-environmental behaviour patterns in individuals and groups.

6.3.3 Dingle Aquarium – Six-month follow-up study

The Friedman test confirmed that for the control group there is a statistically significant difference between pre- (before school tour), post- (directly after the school tour) and post-2- (six months after the school tour) test scores (χ^2=7.721, p=0.021). Children scored higher in the post- and post-2-test than the pre-test in the control group (Figure 6.9). In the treatment group, there was a highly significant difference in total test score between pre-, post- and post-2-test score (χ^2 = 22.503, p <0.001). Students scored better in the post-test and the post-2-test than the pre-test, but slightly less well in the post-2-test than the post-test (Figure 6.9). Throughout, students in the treatment group scored higher than those in the control group (Figure 6.9). These results confirm those of Kuhar et al. (2010) and Jensen et al. (2017), who also found significant increases in scores from pre-visit to post-visit, followed by an increase or a stable score on the delayed post-visit.

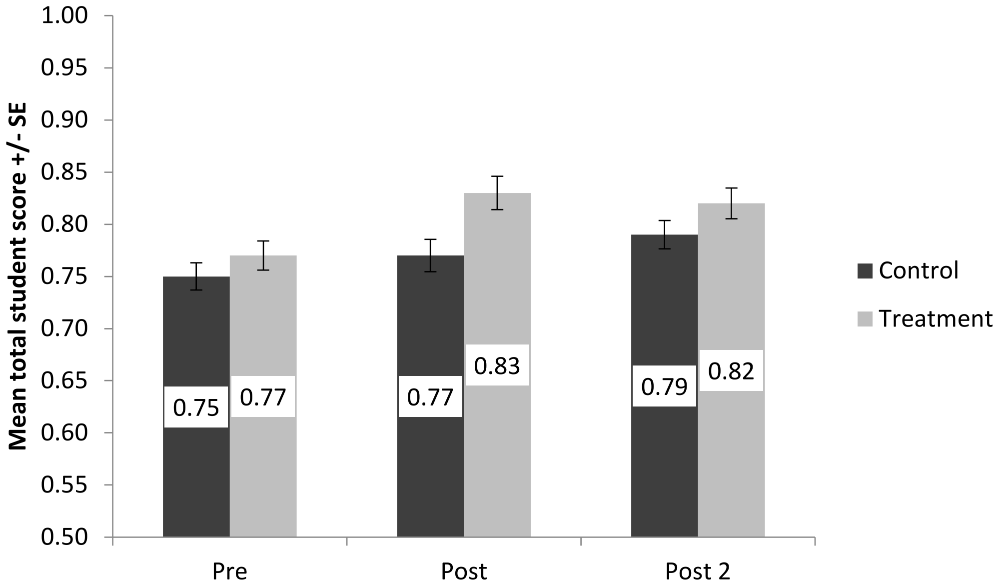
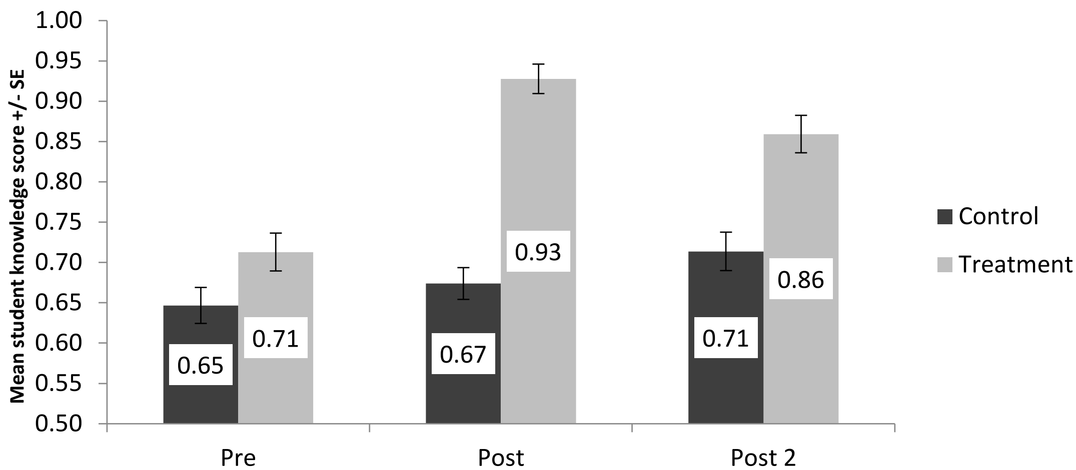


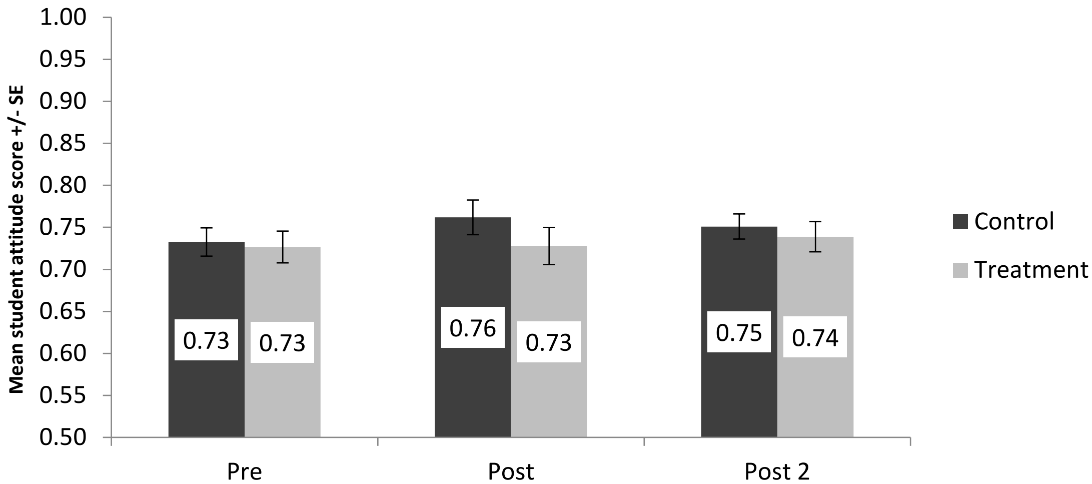
Figure 6.9. The total mean ± SE test scores for control and treatment groups in the pre-, post- and post-2-survey at Dingle Aquarium.

Mean student scores for individual sections of the survey revealed the most variation in knowledge score, both from pre- to post-2-survey and between control and treatment groups (Figure 6.10A). There was little change in attitude score for either group from pre- to post-2-survey (Figure 6.10B). It has been suggested that attitude may be influenced by environmental education, but is slow to manifest (Bogner, 1998); however, the results discovered here do not support that theory. Behaviour score varied slightly (Figure 6.10C). The fact that it was lowest in the pre-survey and highest in the post-2-survey for the control group suggests that this group did need time to assimilate information after the visit. In contrast, the treatment group's behaviour score was lowest on the post-2-survey (Figure 6.10C). Yet, it is encouraging that the behaviour score remained high for both groups six-months after the experience, since previous research that reported that behaviour change does not last (Ballantyne, Packer & Falk, 2011). It should be noted that these data are group scores and do not reflect changes in individual learning.

A.



B.



C.

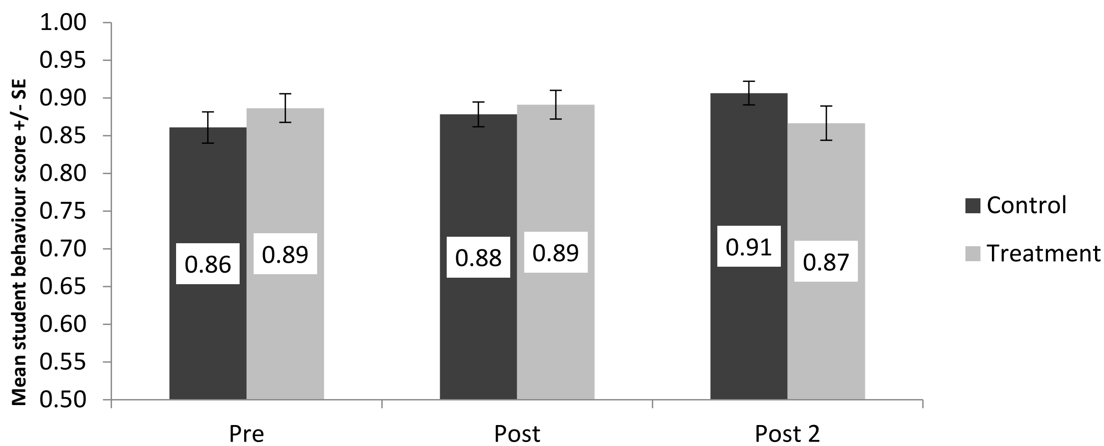


Figure 6.10. The mean ±SE test scores for control and treatment groups in the pre-, post- and post-2-survey at Dingle Aquarium for A) knowledge, B) attitude and C) behaviour.

General linear model: Knowledge

The general linear model for knowledge showed that only condition had a significant effect on knowledge score from post- to post-2-survey scores (p=0.001) (Figure 6.11) (see Appendix, Table A4 of this chapter for the complete model). Students in the control groups (41%) were more likely than those in the treatment group (7%) to have an increase in their knowledge scores between post-survey and post-2-survey (Figure 6.11). In the treatment group, 41% of students experienced a decrease in knowledge between post- and post-2-survey compared to only 15% in the control group.

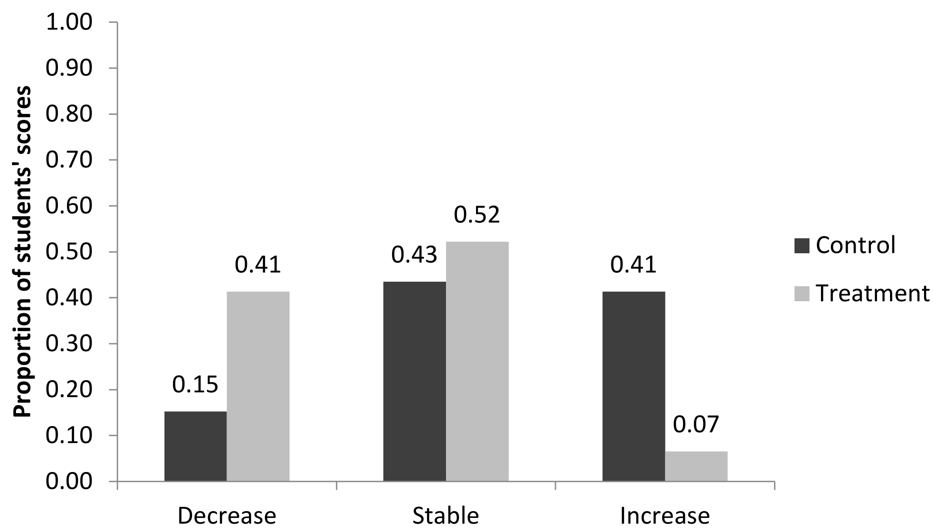


Figure 6.11. The proportion of students whose knowledge scores decreased, remained stable or increased between post and post-2-survey for control and treatment groups.

This surprising result is similar to the findings of Randler et al. (2007), who suggest three possible reasons for this outcome. First, it is possible that the children in the treatment group may have shared their experience with the children in the control group, causing an increase in control group scores, which the authors equate to peer-tutoring and is more likely to occur with girls (Randler et al., 2007). Second, in the Randler et al. (2007) study the results of the tests were discussed with both groups after the post-test. In the current study, to the best of my knowledge, this did not occur. Finally, Randler et al. (2007) point out that repeated testing may increase scores (Ebbinghaus, 1964; Karpicke and Roediger, 2007). However, this should affect both groups equally not just the control group. Additionally, according to Bogner (1998) it is possibly more difficult to build on the already high knowledge scores of the treatment group in the post-test (see Figure 6.10A). The treatment group, with the benefit of the educational intervention, may have assimilated knowledge faster than the control group, who may have benefited from time and intervening experiences to score better on the survey six months after the experience in the area of knowledge.

General linear model: Attitude

Similar to previous findings of this study, the general linear model revealed that none of the variables that were tested affected attitude score (see Appendix, Table A5 of this chapter for the complete model).

General linear model: Behaviour

The general linear model for behaviour revealed that condition ($p=0.03$) (Figure 6.12) and gender ($p=0.022$) (Figure 6.13) had a significant effect on behaviour score from post- to post-2-survey (see Appendix, Table A6 of this chapter for the complete model). Students in the control group (39%) were more likely than those in the treatment group (22%) to have an increase in behaviour score and least likely (22%) to have a decrease in behaviour compared to 35% in the treatment group from post- to post-2-survey (Figure 6.12). The reasons for this are not clear. There was little difference in mean group score on the post-survey thus it should be equally possible for either group to increase their behaviour score on the post-2-survey (Figure 6.10C).

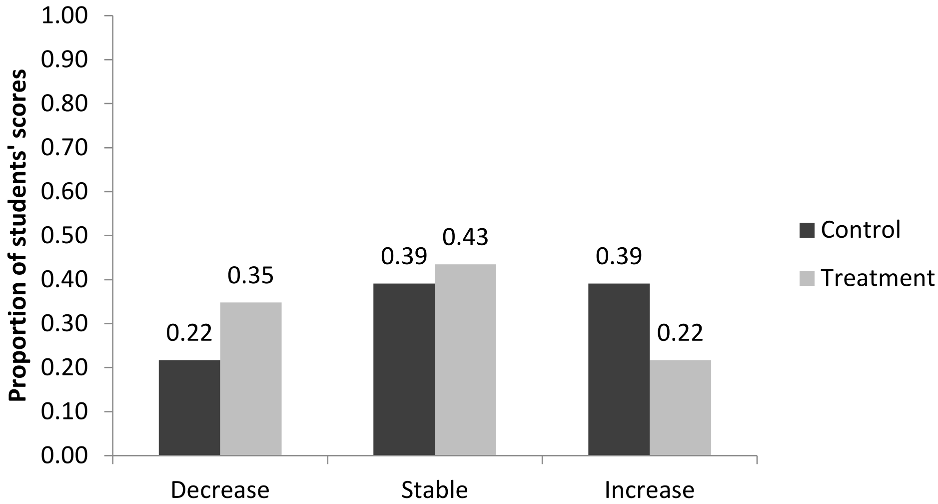


Figure 6.12. The proportion of students whose behaviour scores decreased, remained stable or increased between post- and post-2-survey for control and treatment groups.

Gender also affected the behaviour score, with 41% of girls showing an increase in their behaviour scores compared to only 21% of boys between post- and post-2- survey (Figure 6.13). Again, this is a similar result to Randler et al. (2007), who found that girls had higher scores than boys on the retention test, which the authors attributed to girls discussing the experience. The results found at Dingle Aquarium support this, and also offer evidence that reinforcing experiences and discussions promote long-term learning (Ballantyne and Uzzel, 1994; Adelman et al., 2000). Interestingly, and in contrast, Borchers et al. (2014) reported that in the Côte d'Ivoire boys had higher scores on the post-test than girls, but in the local culture boys had more opportunity to gather and discuss the experience than girls. It is important that environmental educators are aware of this and encourage discussion of the experience for both genders. Although Ballantyne, Packer & Falk (2011) found that first-time visitors reported greater long-term learning than repeat visitors, having previously visited an aquarium did not affect learning in the current study. Of course, it is always possible that other variables such as the media and subsequent zoo visits may contribute to the retention test scores, but this is almost impossible to control (Jensen et al., 2017).

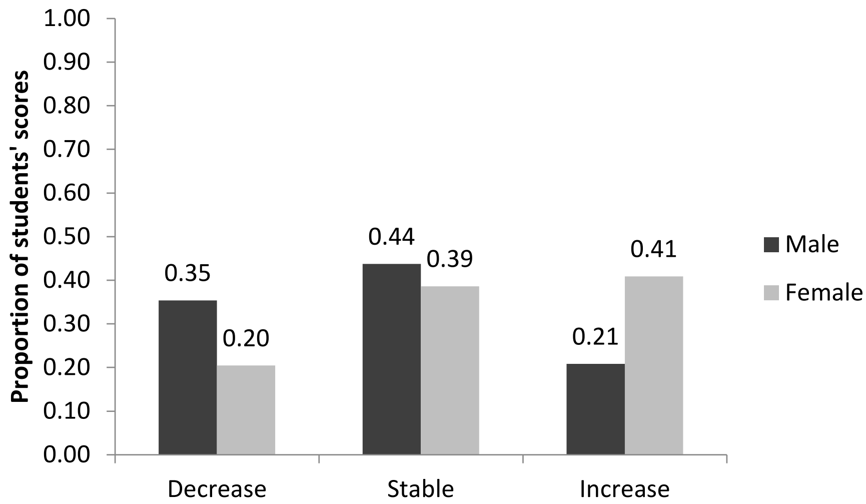


Figure 6.13. The proportion of students whose behaviour scores decreased, remained stable or increased between post- and post-2-survey for male and female students.

Qualitative question: Control group

Overall little variation in responses occurred in the control group between the three surveys (see Figure 6.14). Most students (30%) answered with ‘care for animals’ on the pre-survey, followed by ‘give them space’ (26%). These responses did not change on the post-survey. However, on the post 2-survey the response choice ‘care for animals’ had decreased to 23%, but ‘give them space’ received the most responses and had increased to 32%. There was a 10% increase on the post-survey for the response not to annoy animals, but this was down slightly to 16% on the post-2-survey, but still higher than the pre-survey (9%). Similar to the five-day Fota camp control group, even though this concept was not specifically discussed, these children may have picked up this educational message possibly from signage in the aquarium or from discussion with their peers in the treatment group. There was little variation in food-related responses on the three surveys. Interestingly 9% of students on the pre-survey and post-2-survey responded ‘to give animals enrichment’, but this decreased to 2% on the post-survey. Since there was no specific discussion of enrichment with this group, one theory is that they were aware of enrichment before their visit, but if the experience provided no reinforcement of this concept, the response to give enrichment decreased on the post-survey but returned to pre-

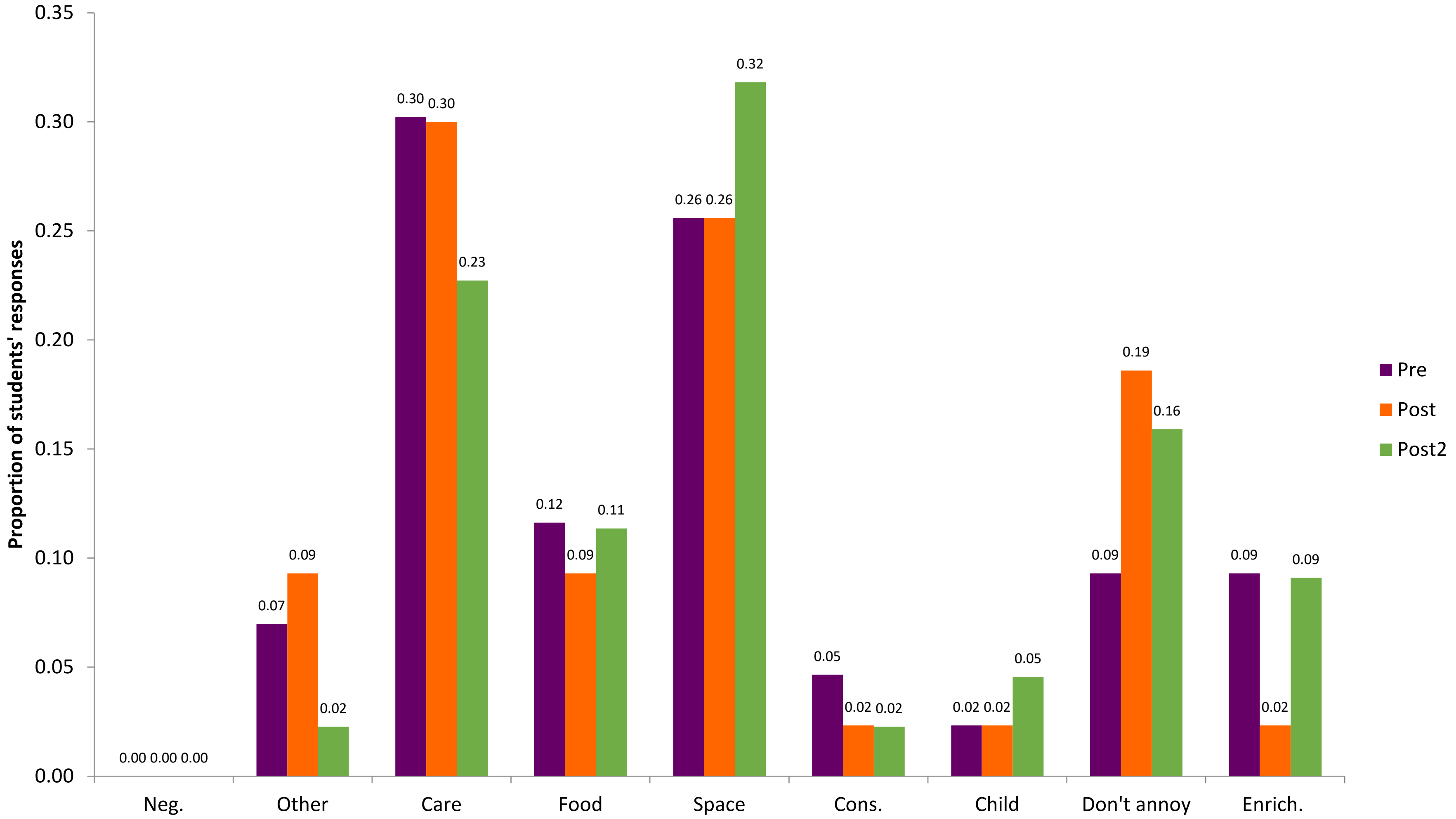


Figure 6.14. Student responses in the control group for the question 'how can you help zoo animals?' on the pre-, post- and post-2-survey.

visit levels six months later. Conservation related responses decreased slightly from pre- to post- and post-2-survey, conversely child-centred responses increased slightly from pre- and post- to post-2-survey. There were no negative responses during any of the surveys in the control group.

Qualitative question: Treatment group

More variation occurred between the three surveys in the treatment group than the control group in response to the question ‘how can you help zoo animals?’ (Figure 6.15). The most common response on the pre-survey in the treatment group was to give animals space (30%), followed closely by to care for them (27%). There were few responses relating to food, conservation or enrichment on the pre-survey and no negative responses. On the post-survey there was a 10% increase in the students responding ‘don’t annoy animals’. Food-related, other, negative and answers including enrichment all increased slightly, but child-centred responses decreased slightly. The most frequent answer on the post-2 survey for the treatment group was not to annoy animals (31%). There was also an increase in the percent of children responding to give animals enrichment (13%). However, space-related responses increased to 24% on the post-2-survey but were still lower than on the pre-survey. Child-centred responses and negative responses were unchanged from post- to post-2 survey. There was a large decline (18%) from pre- to post-2-survey in the non-specific response to care for animals and food-related responses returned to pre-survey level of 2%. The treatment group on the post-2-survey gave the highest level (7%) of conservation related responses, such as stop polluting oceans.

Since this is aggregate data rather than individual responses it is not possible to determine with certainty, but it seems likely that the general response ‘care for animals’ commonly given at the start of the study was replaced with give enrichment and don’t annoy animals, indicating a greater depth of learning. In the post-2-survey the conservation-type response increased, possibly suggesting that children had become more ‘tuned-in’ to conservation messages since their visit to the aquarium (Jensen et al., 2017).

Although the treatment group were less likely than the control group to increase their behaviour score between post- and post-2-survey (Figure 6.10C), they were almost twice

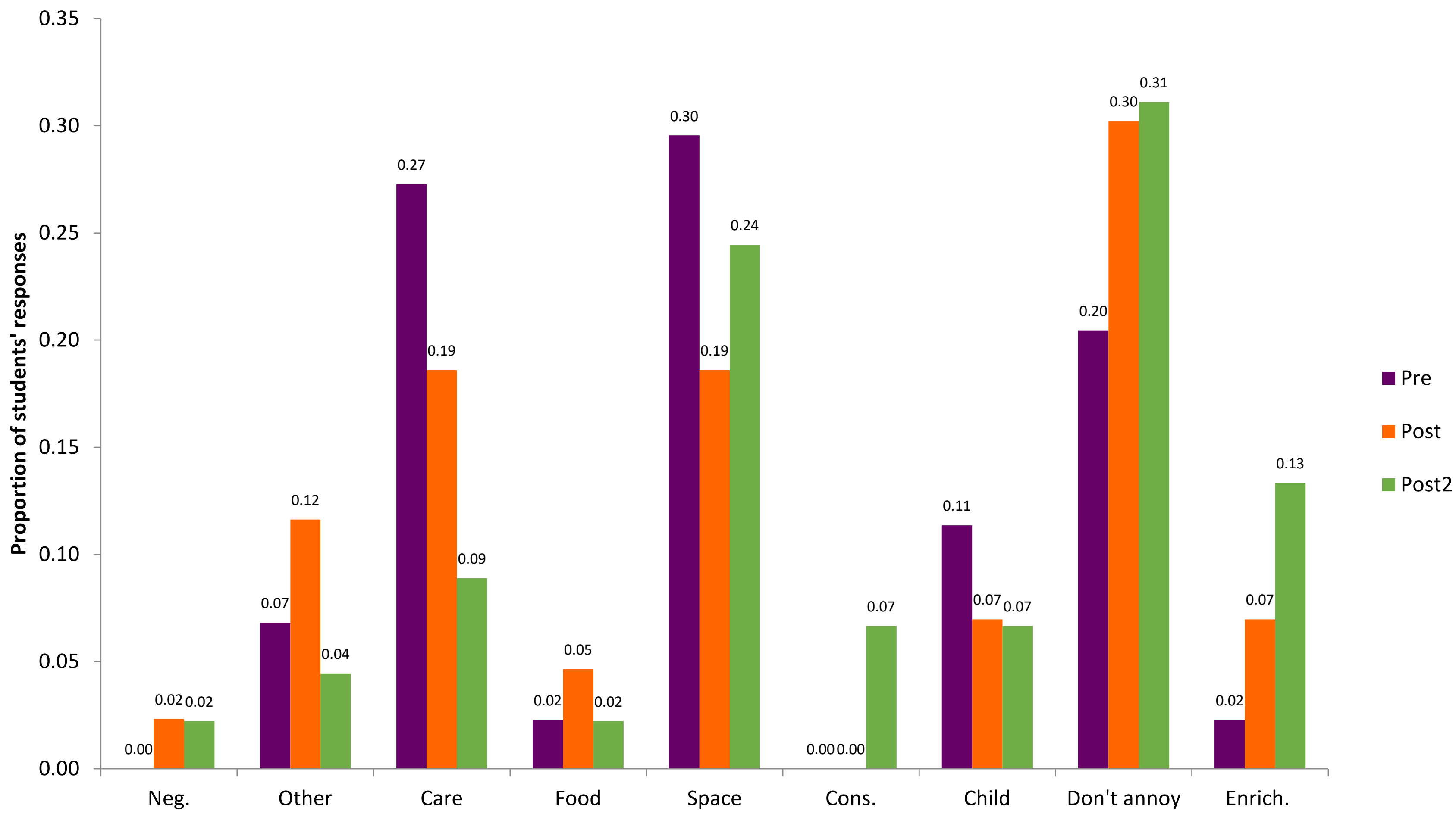


Figure 6.15. Student responses in the treatment group for the question 'how can you help zoo animals?' on the pre-, post- and post-2-survey.

as likely to respond to the qualitative question of how to help zoo animals with the response ‘don’t annoy them.’ This may indicate that children do not make connections between their own actions and helping animals, suggesting a lack of self-empowerment vital to environmental education (Hungerford and Volk, 1990). This should be explored further in future research.

6.4 General discussion

The results revealed that knowledge and behaviour were both affected by the length of the experience and in the six-month follow-up study. However, throughout the study, attitude changed very little, which is similar to what Lukas and Ross (2005) found in their study on visitor attitude towards great apes. This is in contrast to other studies that have reported significant attitude change after an environmental educational experience (Bogner, 1998; Borchers et al., 2014), although, ultimately, Bogner (1998) concluded that more intense and long-term interventions are needed to change long-held values. Yet, long-held attitudes are difficult to change (Ajzen and Fishbein, 1980) and brief educational experiences may not be sufficient to influence attitude (Falk and Dierking, 2000). Another possibility for the lack of change in attitude in the current research is that the attitudinal questions pertained specifically to captive animals and to learning in the zoo, and not the environment. For example, a child with a propensity to care for animals and the environment may have strongly agreed that zoo animals are bored. But if that same child had been asked ‘do you think deforestation is okay?’ there could have been a different response. Since pro-environmental attitudes are considered a predictor of positive environmental behaviour or actions (Ajzen, 1991; Mittelstaedt et al., 1999; Borchers et al., 2014), it is somewhat surprising that the current study has uncovered positive behaviour changes, but not attitudinal change. However, when considered in the context that children who answered the attitude section negatively, may be concerned about the welfare implication of animals in captivity (they are bored and unhappy), it is understandable that they then responded that it is wrong to touch or feed animals in the behaviour section. In the future, it would be useful to try to coordinate questions in order to make connections between attitude and behaviour. These findings indicate that the reasons for keeping animals in captivity and the potential benefits should be introduced into the curriculum.

Additionally, since the results showed previous attendance at a Fota camp was a variable that affected attitude and behaviour score, zoos and aquariums should consider potential differences in children's understanding at the start of their educational experience (Dierking et al., 2004; Lukas and Ross, 2005; Ballantyne, Packer & Falk, 2011). It could be beneficial for children with a greater understanding, if the curriculum was more advanced to suit their higher level of knowledge, introducing more complex ecological concepts such as biodiversity, extinction and actions to help the environment. Furthermore, the camp curriculum should progress from year to year, to benefit repeat campers by reinforcing and building on already existing knowledge and a pre-existing propensity to care for the environment (Bexell et al., 2013). Based on the Prochaska Model of Behavioural Change, Dierking et al. (2004) surmised that visitors are in different stages of learning. The authors explained that zoos tend to target visitors in the early stages of learning, by making a large effort to convince visitors that there are real environmental problems. Yet, for visitors who have moved beyond the early stages of learning, such as the children attending camps in the current study, more effort is needed in educating visitors about what actions they can take to help the environment (Dierking et al., 2004). The introduction of hands-on activities like the ones completed during the educational intervention may help to achieve this. While these data only reflect the knowledge, attitude and behaviour scores of children attending a camp at Fota Wildlife Park, further investigation should be carried out at other institutions like Dingle Aquarium to ascertain generalisability of these data. Certainly, it seems likely that children who chose to attend learning experiences at informal science centres may come with higher than average levels of knowledge, and the curriculum should be tailored to challenge, inspire and reinforce positive behaviour. Educators should help students formulate realistic goals, so that children learn personal actions to help animals and the environment (Mittelstaedt et al., 1999).

There is some evidence particularly with camp children, who had both high knowledge and behaviour scores before and after the experience that knowledge might in fact influence behaviour. However, previous studies suggesting that increased knowledge leads to improved behaviour are controversial with widely varying results (Bogner, 1998; Dierking et al., 2004). Yet, it seems intuitive that a basic knowledge of ecological concepts must be required for developing pro-environmental behaviours (see Chapter 9 for further details). Like the results presented by Bogner (1998) and Bexell et al. (2013), the results of the current study suggest a connection between knowledge gain and behaviour scores during the longer educational experience. However, even if increases in knowledge lead to improved behaviour, this does not guarantee that it will persist. It was not possible for the current study to conduct a follow-up study with the camp children, but future research should consider retention testing after a long term educational experience. Generally, the findings from this research are encouraging and suggest that longer educational experiences may lead to a greater depth of understanding and pro-environmental behaviour, and that learning does last beyond the immediate educational experience.

6.5 Conclusions

1. During the Fota Wildlife Park camp, participation in the educational intervention was the most significant predictor of knowledge gain. Children in the treatment group were more likely than those in the control group to experience an increase in knowledge between pre- and post-survey. Additionally, children in the treatment group had no decrease in behaviour score between pre- and post-survey.
2. Both attitude and behaviour were influenced by previous attendance at a camp at Fota Wildlife Park. Children who had never attended a camp before were more likely than those who had to have increases in attitude and behaviour scores between pre- and post-survey.
3. Camp children had higher knowledge and behaviour scores than school tour children on the pre-survey. For treatment groups, school tour children were more likely to gain in knowledge and camp children were more like to experience increases in behaviour score between pre- and post-survey.
4. Treatment groups scored consistently higher than control groups on the pre-, post- and post-2-survey at Dingle Aquarium. However, control groups were more likely than treatment groups to experience gains in knowledge and behaviour scores between post- and post-2-survey than treatment groups. Girls were also more likely to have increases in behaviour score between the post- and post-2-test than boys.

5. Throughout the research more variation occurred in the treatment group's response to the qualitative question. There were indications of deeper learning for camp groups than school tour groups and for treatment groups than control groups.

6.6 References

Adelman, L. S., Falk, J. H. & James, S. (2000). Assessing the National Aquarium in Baltimore's impact on visitors' conservation knowledge, attitude and behaviour. *Curator*, 43(1), 33-61.

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, 50(2), 179–211.

Ajzen, I. & Fishbein, M. (1980). Understanding attitudes and predicting social behavior. Engelwood Cliffs, NJ: Prentice-Hall.

Ballantyne, R., Packer, J. & Falk, J. (2011). Visitors' learning for environmental sustainability: Testing short-and long-term impacts of wildlife tourism experiences using structural equation modelling. *Tourism Management*, 32(6), 1243-1252.

Ballantyne, R., Packer, J. & Sutherland, L. A. (2011). Visitors' memories of wildlife tourism: Implications for the design of powerful interpretive experiences. *Tourism Management*, *32*(4), 770-779.

Ballantyne, R. & Packer, J. (2002). Nature-based excursions: School Students' perceptions of Learning in Natural Environments. *International Research in Geographical and Environmental Education*, 11(3), 218–236.

Ballantyne, R. & Uzzell, D. (1994). A checklist for the critical evaluation of informal environmental learning experiences. *International Journal of Environmental Education and Information*. 13(2), 111-124.

Bexell, S. M., Jarrett, O. S. & Ping, X. (2013). The effects of a summer camp program in China on children's knowledge, attitudes, and behaviors toward animals: A model for conservation education. *Visitor Studies*, 16(1), 59-81.

Bogner, F. X. (1998). The influence of short-term outdoor ecology education on long-term variables of environmental perspective. *The Journal of Environmental Education*, 29 (4), 17-29.

Borchers, C., Boesch, C., Riedel, J., Guilahoux, H., Ouattara, D. & Randler, C. (2014). Environmental education in Côte d'Ivoire/West Africa: Extra-curricular primary school teaching shows positive impact on environmental knowledge and attitudes. *International Journal of Science Education, Part B*, 4(3), 240-259.

Dierking, L. D., Adelman, L. M., Ogden, J., Lehnhardt, K., Miller, L. & Mellen, J. D. (2004). Using a behavior change model to document the impact of visits to Disney's Animal Kingdom: A study investigating intended conservation action. *Curator: The Museum Journal*, 47(3), 322-343.

Ebbinghaus, H. (1964). *Memory: A contribution to experimental psychology* (H. A. Ruger & C. E. Bussenius, Trans.) NewYork: Dover (original work published 1885).

Emmons, K. M. (1997). Perceptions of the Environment while Exploring the Outdoors: a case study in Belize. *Environmental Education Research*, 3(3), 327–344.

Falk, J. H. & Dierking, L. D. (2000). *Learning from Museums: visitor experiences and the making of meaning*. Walnut Creek, CA. Alta Mira Press.

Farmer, J., Knapp, D. & Benton, G. M. (2007). An Elementary School Environmental Education Field Trip: Long-Term Effects on Ecological and Environmental Knowledge and Attitude Development. *The Journal of Environmental Education*, *38*(3), 33–43.

Fota Wildlife Park (2018). Kids Camps: Learn and Play. Date last accessed April 10, 2018, www.fotawildlife.ie/education/camps-play-learn.

Hungerford, H. R. & Volk, T. L. (1990). Changing learner behavior through environmental education. *The Journal of Environmental Education*, 21(3), 8-22.

Jensen, E. (2014). Evaluating children's conservation biology learning at the zoo. *Conservation Biology*, 28(4), 1004-1011.

Jensen, E. A., Moss, A. & Gusset, M. (2017). Quantifying long-term impact of zoo and aquarium visits on biodiversity-related learning outcomes. *Zoo Biology*, 36(4), 294-297.

Karpicke, J. D. & Roediger, H. L. (2007). Repeated retrieval during learning is the key to long-term retention. *Journal of Memory and Language*, 57(2), 151-162.

Kuhar, C. W., Bettinger, T. L., Lehnhardt, K., Townsend, S. & Cox, D. (2007). Evaluating the impact of a conservation education programme in the Kalinzu Forest Reserve, Uganda. *International Zoo Educators Journal*, 43, 12-15.

Kuhar, C. W., Bettinger, T. L., Lenhardt, K., Tracy, O. & Cox, D. (2010). Evaluating for long-term impact of an Environmental Education Program at the Kalinzu Forest Reserve, Uganda. *American Journal of Primatology*, 72, 407-413.

Leeming, F. C., Dwyer, W. O., Porter, B. E. & Cobern, M. K. (1993). Outcome research in environmental education: A critical review. *The Journal of Environmental Education*, 24(4), 8-21.

Lukas, K. E. & Ross, S. R. (2005). Zoo visitor knowledge and attitudes toward gorillas and chimpanzees. *The Journal of Environmental Education*, *36*(4), 33.

Mann, J. B., Ballantyne, R. & Packer, J. (2018). Penguin Promises: encouraging aquarium visitors to take conservation action. *Environmental Education Research*, *24*(6), 859-874.

Mittelstaedt, R., Sanker, L. & Vander Veer, B. (1999). Impact of a week-long experiential education program on environmental attitude and awareness. *Journal of Experiential Education*, 22(3), 138-148.

Moss, A., Jensen, E. & Gusset, M. (2015). Evaluating the contribution of zoos and aquariums to Aichi Biodiversity Target 1. *Conservation Biology*, 29(2), 537-544.

Ogden, J. & Heimlich, J. E. (2009). Why focus on zoo and aquarium education? *Zoo Biology*, 28(5), 357–60.

Patrick, P. G., Matthews, C. E., Ayers, D. F. & Tunnicliffe, S. D. (2007). Conservation and education: prominent themes in zoo mission statements. *The Journal of Environmental Education*, 38(3), 53-60.

Randler, C., Baumgärtner, S., Eisele, H. & Kienzle, W. (2007). Learning at workstations in the zoo: A controlled evaluation of cognitive and affective outcomes. *Visitor Studies*, 10(2), 205-216.

Roe, K., McConney, A. & Mansfield, C. F. (2014). The role of zoos in modern society—A comparison of zoos' reported priorities and what visitors believe they should be. *Anthrozoös*, 27(4), 529-541.

UNESCO. 1978. Final report: Intergovernmental Conference on Environmental Education, Organized by UNESCO in Cooperation with UNEP, Tbilisi, USSR, October 14–26, 1977, Paris: +UNESCO ED/MD/49.

Chapter 6: Appendix

Table A1. Variables originally included in model for knowledge - Fota Camp

Independent Variables	Estimate	Standard error	t value	P - value
Condition	1.501	0.447	3.359	0.001*
Science show	3.951	0.454	0.870	0.386
Gender	0.428	0.423	1.011	0.314
Camp before	0.002	0.205	0.096	0.924
Zoo before	2.547	2.163	1.178	0.242
Nature shows TV	-0.000	0.000	-0.508	0.613

* Variables left in the model presented within the chapter are marked with an asterisk.

Table A2. Variables originally included in model for attitude - Fota Camp

Independent Variables	Estimate	Standard error	t value	P - value
Condition	0.305	0.382	0.798	0.427
Science show	-0.135	0.389	-0.348	0.729
Gender	-0.092	0.362	-0.254	0.800
Camp before	-0.386	0.176	-2.199	0.030*
Zoo before	1.220	1.852	0.659	0.511
Nature shows TV	-0.000	0.000	-0.709	0.480

* Variables left in the model presented within the chapter are marked with an asterisk.

Table A3. Variables originally included in model for behaviour - Fota Camp

Independent Variables	Estimate	Standard error	t value	P - value
Condition	0.698	0.317	2.202	0.040*
Science show	0.102	0.322	0.317	0.752
Gender	0.148	0.300	0.491	0.625
Camp before	-0.425	0.146	-2.915	0.004*
Zoo before	-0.884	1.536	-0.576	0.566
Nature shows TV	0.000	0.000	0.343	0.737

* Variables left in the model presented within the chapter are marked with an asterisk.

Table A4. Variables originally included in model for knowledge - Dingle 6-month follow-up

Independent Variables	Estimate	Standard error	t value	P - value
Condition	-1.367	0.370	-3.697	< 0.001*
Gender	0.170	0.370	0.460	0.646
Aquarium before	0.328	0.286	1.150	0.253
Nature shows TV	-0.059	0.225	-0.261	0.795

* Variables left in the model presented within the chapter are marked with an asterisk.

Table A5. Variables included in model for attitude - Dingle 6-month follow-up

Independent Variables	Estimate	Standard error	t value	P - value
Condition	0.466	0.515	0.905	0.368
Gender	0.524	0.513	1.021	0.310
Aquarium before	0.327	0.397	0.823	0.413
Nature shows TV	-0.492	0.314	-1.570	0.120

Table A6. Variables originally included in model for behaviour - Dingle 6-month follow-up

Independent Variables	Estimate	Standard error	t value	P - value
Condition	-0.681	0.315	-2.158	0.034*
Gender	0.708	0.315	2.252	0.027*
Aquarium before	-0.105	0.243	-0.431	0.668
Nature shows TV	0.074	0.192	0.385	0.701

* Variables left in the model presented within the chapter are marked with an asterisk.

Section C

Connections within the zoo

Chapter 7

Zoological education: Can it change behaviour?

A modified version of this chapter has been submitted to the journal Zoo Biology in the following form; Collins, C., Quirke, T., McKeown, S., Flannery, K., Kennedy, D. & O'Riordan, R. Zoological education: Can it change behaviour?

Abstract

The behaviour of zoo visitors towards captive animals is a largely under-studied area of research, even though behaviour change should be the ultimate goal of zoological education. Evidence is beginning to emerge that certain behaviours by visitors, like shouting, banging and staring, can negatively affect animals. Previous methods to minimise negative visitor behaviour have primarily focused on physical exhibit alterations, such as barriers. The current study used an educational intervention (EI) in an attempt to decrease negative behaviour and promote positive animal welfare. The first aim of the study was to reduce negative visitor behaviour, and the second was to assess if either an educational intervention or a reduced rate of negative visitor behaviour led to a change in the zoo-housed animals' behaviour. The visitors were groups of children, while three species of captive animals were studied: ring-tailed lemurs (*Lemur catta*), Humboldt penguins (*Spheniscus humboldti*) and Gentoo penguins (*Pygoscelis papua*). The children were studied under two conditions: 1) control groups who did not receive an educational intervention and 2) treatment groups who received the educational intervention. Children's and animals' behaviour was simultaneously recorded using behaviour and scan sampling. The results showed a statistically significant reduction in negative behaviour by the children for the treatment groups at all three animal exhibits. Findings varied for the animals' behaviour. Generally, there was no corresponding change in the animals' behaviour associated with the rate of negative behaviour or the presence of a treatment or control group, but there is some indication that the lemurs' behavioural diversity level decreased when children's negative behaviour increased. In conclusion, education programmes in zoos could be enhanced by introducing programmes aimed at reducing negative visitor behaviour, which could ultimately lead to pro-conservation behaviour.

7.1 Introduction

Literature from the last two decades has shown that despite many different variables of the zoo setting, visitors have the potential to affect the behaviour of a wide variety of species as they view them (Wood, 1998; Mallapur and Chellam, 2002; Stevens et al., 2013; Collins and Marples, 2015). One of the factors that may affect an animal's response to visitors, is the behaviour of the visitors as they view the animals. For example, visitor noise has been found to be a contributory cause of agitation, aggression and possibly reduced welfare in captive animals (Birke, 2002; Keane, 2005; Morgan and Tromborg, 2007; Quadros et al., 2014). Other active visitor behaviours like banging, staring, shouting and offering food have also been found to affect zoo-housed animals (Nimon and Dalziel, 1992; Wood, 1998; Birke, 2002; Choo et al., 2011 Sherwen et al., 2014), though the implications of this are not always clear.

Previous studies have sought to control negative visitor behaviour and improve animal welfare through physical means such as barriers and sound-proofing material (Blaney and Wells, 2004; Keane, 2005), which produced mixed results. More rarely researchers have appealed to visitors' emotions or intellect with signs or the presence of staff to reduce negative visitor behaviour (Kratochvil and Schwammer, 1997; Keane, 2005; Sherwen et al., 2014). Aquarium fish are known to be disturbed by visitors banging on glass, and in a seminal study Kratochvil and Schwammer (1997) reduced this behaviour by posting three different types of signs at the aquarium. The sign 'only loonies would knock' was most effective at minimising negative visitor behaviour (Kratochvil and Schwammer, 1997). However, there was no research on whether fish welfare improved. Keane (2005) used educational posters and signs asking visitors to be quiet at a gorilla (*Gorilla gorilla gorilla*) exhibit, where visitor noise was known to induce aggressive behaviour in a male gorilla. The findings were inconclusive, and the gorillas' behaviour varied with no clear pattern emerging (Keane, 2005). More recently, Sherwen et al. (2014) considered the effect of visitor behaviour on meerkats (*Suricata suricatta*). The authors used signage and researchers dressed as zoo staff to communicate to visitors to be quiet and not to interact with the animals. While the authors do report a reduction in noise and negative visitor behaviour during the treatment condition, they found no corresponding effect on meerkat behaviour (Sherwen et al., 2014).

Another way to control negative visitor behaviour could be through purposefully educating zoo visitors about how their behaviour could affect captive animals (Fernandez et al., 2009; Quadros et al., 2014, Hosey, 2013), but rarely has this been tested. One pioneering study developed an educational intervention to try to ‘control’ visitor behaviour during a wild dolphin feeding programme (Orams and Hill, 1998). Orams and Hill (1998) argue that educating visitors could be as effective as physical means at controlling visitor behaviour. By quantifying inappropriate behaviour, the study revealed that eco-tourists who had participated in a structured education programme about dolphins were significantly less likely to engage in inappropriate behaviour during a dolphin feeding session than the control group, who did not attend an education programme (Orams and Hill, 1998). While that study concerns eco-tourists rather than zoo visitors, the implications of this research are significant for the current research. Orams and Hill (1998) demonstrate that education can be an effective way to control inappropriate visitor behaviour, though, unfortunately, they did not consider any associated reduction of negative visitor behaviour on dolphin behaviour.

Similar to the current study, children’s behaviour was monitored during a conservation education summer camp (five-days) in China (Bexell et al., 2013). Students were evaluated (using a mixed method approach) for changes in knowledge, attitude and behaviour towards animals and the environment at the start and finish of the camp (Bexell, 2006; Bexell et al., 2013). Camp curriculum included five units which consisted of a tour and introduction to animals, lessons on caring for animals, animal observations, presentations by animal experts and understanding biodiversity (Bexell, 2006). The authors base the premise for their study, and the curriculum of the camp on the work of Myers and Saunders (2002), who propose that children’s understanding of animals and compassion towards them comes from direct interaction with them. Bexell et al. (2013) aimed to develop children’s bonds with animals through personal experience, and they did detect a significant increase in knowledge, specifically knowledge about how to care for animals and the environment. However, the most important finding was the observable on-site change in behaviour. As the week progressed, campers exhibited fewer negative behaviour towards animals and the environment. The authors conclude that the campers have gained cognitive empathy or an understanding of what animals might feel, which can ultimately lead to positive conservation action. Bexell et al. (2013) have shown that not only is it possible to develop a curriculum that positively affects behaviour, but that through their innovative ethogram, developed to measure children's behaviour, it is also possible to measure behaviour on-site, as discussed by Smith et al. (2008). Although, they did not report any effect of this change on the animals' behaviour nor did they include a control group in their research.

Luebke et al. (2016) found that across several zoos and different species, if visitors were able to observe animal behaviour and have an up-close experience, a positive emotional response was reported, which may lead to pro-conservation behaviour. Interestingly, the type of animal behaviour observed did not have much influence on the visitors' response as long at the animals were visible (Luebke et al., 2016). This is in contrast to Altman (1988) who reported that visitors learn more from animals that engaged in animated activity. Luebke et al. (2016) did not define what an up-close encounter involved and the visitors themselves reported the animal behaviour they observed. Additionally, an interaction that a visitor may consider to be a positive emotional experience, such as making eye contact, could be frightening or harmful to an animal.

Kratochvil and Schwammer (1997) speculate that the majority of disturbance (banging on glass) is instigated by younger visitors. Although there is minimal research to support this suggestion, children and school groups do constitute a large number of zoo visitors each year, yet they are a generally neglected area of visitor research (Jensen, 2011). There is little research examining the efficacy of zoo education programmes, though recently a study found that scientific learning in school groups visiting zoos almost doubled when coupled with an educational presentation given by the zoo (Jensen, 2014). Yet, zoological education programmes should not only aim for their students to acquire knowledge, but also develop pro-conservation behaviours as a result of participating in their programmes (Ogden and Heimlich, 2009). Typically, pro-conservation behaviour change is aimed at adults, and includes actions like recycling, buying environmentally friendly products or donating money to conservation causes; however, these actions can be challenging to reliably measure and difficult to attribute to a zoo's education programme (Smith et al., 2008). Kuhar et al. (2010) state that ultimately environmental education should progress one step beyond pro-conservation behaviour change to show a significant biological impact, such as improved animal welfare.

Fota Wildlife Park attracts many children and school groups each year, and most species are in close proximity to visitors. Therefore, visitors touching, chasing, feeding and throwing objects at animals is a concern. Although these behaviours are discouraged by Fota, preliminary investigations found that they do occur. At Dingle Aquarium, visitors have more limited access to the animals, but camera flashes and banging on the glass at the penguin exhibit are a concern, and although signs are present asking visitors not to engage in these behaviours, they still occur. The current research is one of the first studies to empirically test the effectiveness of educating visitors, with an objective of reducing negative visitor behaviour, and simultaneously to observe the captive animals' behaviour for any indication of a behavioural response to different visitor conditions.

The aims of this part of the research were to:

1) Investigate the usefulness of an educational intervention at reducing negative visitor behaviour towards captive animals.
2) Identify if there is any corresponding change in the behaviour of three species of captive animal as a result of being viewed by visitor groups that have participated in the educational intervention (EI) or groups that engaged in a lower rate of negative behaviour.

7.2 Methodology

Study sites and animals

The research was carried out at Fota Wildlife Park and Dingle Oceanworld Aquarium (see Chapters 3 and 4 for details) between October 2013 and August 2016 (See Table 7.1).

Table 7.1. Details of study sites, exhibits, animals and observation dates.

Study site	Animals observed	Observation dates and times	No. of animals	Enclosure dimensions (m^2)
Fota Wildlife Park	Ring-tailed lemurs (*Lemur catta*)	October 2013, April – October, 2014 – 2015, April – August 2016 11:00 – 12:30	8-10 5 – 6 ♀ 3 – 4 ♂	Free-ranging
Fota Wildlife Park	Humboldt penguins (*Spheniscus humboldti*)	April – October 2014 - 2015 April – August 2016 11:00 – 12:30	24 – 31 sex unidentified	$61m^2$
Dingle Aquarium	Gentoo penguins (*Pygoscelis papua*)	May 2014 – 2016 11:00 – 15:00	12 8 ♀ 4 ♂	$35m^2$

At Fota Wildlife Park, visitors can directly approach the lemurs, but are discouraged from touching and feeding them by signs and staff (Figure 7.1). Throughout the study, 'lemur patrol' staff were always present to manage and protect the free-ranging lemur group. The lemurs always had access to a sheltered hut and were fed twice per day, though natural foraging also contributed to their diet (see Chapter 3 for details). The weather during the study was generally good because children were not able to tour the park in inclement conditions, temperature varied from 12 – 20°C. Results from Chapter 3 of this thesis indicated that limited interactions did occur between visitors and ring-tailed lemurs. However, since the lemurs' behaviour response to visitors was limited the lemurs' welfare was not affected by including them in this part of the study, which purposely brought large groups of children in close proximity to them.

Figure 7.1. Signs at Fota Wildlife Park outlining park rules for visitors as they view the lemurs.

The Humboldt penguins included in this study were housed in an outdoor enclosure with a large pond of approximately 25m^2, which is fed by a local tidal inlet (Figure 7.2). This allows the penguins natural foraging opportunities; however, they were also fed a diet of whole fish (smelt and herring), twice a day at approximately 10am and 4pm. A low stone wall (0.50 meters high) with a wooden railing separated the penguins from the viewing public. All of the penguins at Fota were captive born and included both parent-reared and hand-reared birds and individuals of both sexes (Table 7.1). Like the other species included in this study, preliminary observations of the Humboldt penguins indicated some visitor interactions did occur, but the penguins did not appear to be affected by visitors and were therefore a suitable species to include in this study.

Figure 7.2. The Humboldt penguins at Fota Wildlife Park

The study also included the Gentoo penguins at Dingle Aquarium, (see Chapter 4 for details of the enclosure and the birds). Signs were posted at the penguin enclosure at Dingle asking visitors not to climb the artificial rock structures, use flash photography, shout or bang on the glass (see Figure 7.3). Results from Chapter 4 of this thesis found that these Gentoo penguins gave a limited behavioural response to visitors, indicating that their welfare would not be compromised by including them in this part of the research.

Figure 7.3. Sign at Dingle Aquarium penguin exhibit indicating that visitors should not use flash photography.

Child participants

The children that participated in this part of the study were school and camp groups on tour of the park or aquarium (Tables 7.2–7.4) and are generally the same groups that were presented in Chapters 5 and 6 of this thesis. Groups were categorised as control or treatment groups, depending on whether or not they had participated in the educational intervention (EI). Therefore, for the purposes of this chapter, camp treatment groups at the start of the week were classified as control because they had not yet received the educational intervention. For camp control groups, the preliminary results indicate that children's behaviour did not vary significantly from the beginning to the end of the camp week, therefore both pre- and post-observations are included together. At times school groups, that were not involved in the study, arrived to view the penguins. This was an opportunistic way to increase the sample size. During these sessions penguins' behaviour and children's behaviour was recorded as described below and the school group was classified as a control group. Their demographics were estimated to the best ability of the researcher.

Procedure and data collection

Children's behaviour and animals' behaviour were observed and recorded simultaneously by the researcher and a research assistant. To ensure reliability of data, inter-observer reliability (IOR) testing was carried out between the primary researcher and all research assistants involved in recording animal behaviour. If a research assistant was unavailable, then a camera (Veho-MUVI^{TM}MICRO) was used to record the animals' behaviour, in this case intra-observer reliability testing was also carried out (Martin and Bateson, 2007). Although the primary researcher recorded all of the children's behaviour, IOR testing was also conducted for children's behaviour by employing a methodology similar to that of Jensen (2011). This included the primary researcher and a member of staff at Fota or Dingle rating students' overall behaviour on a three-point Likert as: 1 (repeated bad behaviour from many children), 2 (generally good behaviour with a few incidences of negative behaviour) and 3 (the entire group was well behaved).

Animals' and children's behaviour were recorded during two conditions:

1) Control groups, children who had not participated in the EI;

2) Treatment groups, children who had participated in the EI.

Children, who participated in the EI, experienced a one-hour class, during which they made enrichment devices for the penguins and prepared a scatter feed for the lemurs. Additionally, they watched a PowerPoint show about lemurs and penguins and specifically they learned about not touching, feeding or frightening zoo animals. Groups were randomly assigned as either treatment or control. See Chapter 5 for details.

Table 7.2. Details of the composition of school groups that participated in the project at Fota Wildlife Park.

ID	School tour date	Gender	Age	No. of children in group*	Condition	Species observed*
FS141	June 2014	Mix	5 – 6	30	Treatment	P
FS142	June 2014	Mix	6 - 7	30	Control	P
FS145	June 2014	Girls	8 - 9	20	Treatment	P
FS146/7	June 2014	Girls	8 -9	40	Control	P
FS148	June 2014	Girls	9 – 10	18	Treatment	L
FS149	June 2014	Girls	9 - 10	19	Control	L
FS214**	June 2014	Mix	7 - 8	30	Control	P
FS414**	June 2014	Mix	6 - 7	25	Control	P
FS614**	June 2014	Mix	5 - 6	25	Control	P
FS151	June 2015	Mix	11 - 12	25	Treatment	P
FS153	June 2015	Mix	9 - 10	30	Treatment	P
FS154	June 2015	Mix	9 - 10	30	Treatment	P
FS155	June 2015	Mix	9 - 10	30	Control	P
FS156A	June 2015	Mix	10 - 12	15	Treatment	P
FS156B	June 2015	Mix	10 - 12	15	Treatment	P
FS157A	September 2015	Girls	11 - 12	17	Treatment	P

Table 7.2 Continued. Details of the composition of school groups that participated in the project at Fota.

ID	School tour date	Gender	Age	No. of children in group	Condition	Species observed
FS157B	September 2015	Girls	11 - 12	17	Treatment	P
FS158	September 2015	Girls	11 - 12	34	Control	P
FS115**	June 2015	Mix	9 – 10	26	Control	P
FS215**	June 2015	Mix	9 – 10	25	Control	P
FS515**	June 2015	Mix	9 – 10	25	Control	P
FS1015**	June 2015	Mix	9 – 10	30	Control	P
FS161	May 2016	Mix	10 - 12	36	Treatment	P
FS162	June 2016	Mix	10 -11	22	Treatment	P
FS163	June 2016	Mix	9 - 10	26	Control	P

* L=Lemurs only; P=Penguins only; L/P=Lemurs and Penguins for Tables 7.2 and 7.3. ** Denotes groups who were not scheduled participants of the study.

Table 7.3. Details of the composition of camp groups that participated in the project at Fota Wildlife Park.

ID	Camp date	Gender	Age	No. of children in group*	Condition	Species observed**
FC131	October 2013	Mix	7 - 12	5	Control	L
FC141	April 2014	Mix	7 - 12	19,10	Treatment	L/P
FC142	July 2014	Mix	7 – 12	25,24	Treatment	L/P
FC143	August 2014	Mix	7 – 12	17	Control	L/P
FC144	October 2014	Mix	7 – 12	8,7	Treatment	L
FC151	April 2015	Mix	7 – 12	32,10	Control	L/P
FC152	July 2015	Mix	9 - 12	14,11	Control	L/P
FC153	August 2015	Mix	9 - 12	16,15	Treatment	L/P
FC161	March 2016	Mix	7 - 12	17	Treatment	L
FC162	July 2016	Mix	7 - 12	18,19	Control	L/P
FC163	August 2016	Mix	7 - 12	18,16	Treatment	L/P

* Note: number of children per group is approximate in camps, and sometimes varied between pre- and post-camps or species observed; two numbers denote pre, post groups.

Table 7.4. Details of the composition of groups that participated in the project at Dingle Aquarium.

ID	School tour date	Gender	Age	No. of children in group	Condition
DS141	May 2014	Mix	11 - 12	19	Treatment
DS142	May 2014	Mix	11 - 12	30	Treatment
DS143	May 2014	Mix	11 -12	30	Control
DS144	May 2014	Mix	9 - 12	20	Control
DS145	May 2014	Mix	8 - 10	20	Control
DS151	May 2015	Mix	11-12	30	Control
DS152	May 2015	Mix	11-12	24	Treatment
DS153	May 2015	Mix	11-12	25	Control
DS154	May 2015	Mix	11-12	25	Control
DS155	May 2015	Mix	11-12	25	Treatment
DS156	May 2015	Mix	11-12	25	Treatment
DS161	May 2016	Mix	11-12	26	Control
DS162	May 2016	Mix	11-12	25	Treatment

Generally, animal behaviour was recorded using instantaneous scan sampling with a one-minute interval (Martin and Bateson, 2007). However, Humboldt penguin vocalisations at Fota Wildlife Park were recorded using all occurrence sampling (Altmann, 1974). Similar to all occurrence sampling, children's behaviour was recorded using event sampling, when each instance of a specific behaviour which occurred during the observation period was recorded (Sattler, 1988; Bexell et al., 2013).

Ethograms were used by the research assistant to record the animals' behaviour and the primary researcher to record the children's behaviour during each observation (Table 7.5 A-C). Data collection did not occur for thirty minutes before or after feeding times at penguin enclosures. Data collection took place on days that a group of children were available to participate in the study. If two groups visited in one day, control groups viewed the animals first and observations were separated by at least one hour. The length of each observation varied and was guided by staff and school teachers. The research assistant started and finished recording data when signalled to do so by the primary researcher. It is possible that other visitors were present when observations took place;

however, it was observed that generally there were few other visitors present during the scheduled observations.

Table 7.5. Ethograms for the animal and children's behaviour observed at the three study sites (A, B & C).

A. Ring- tailed lemurs at Fota Wildlife Park	
Behaviour	**Definition**
Inactive	Lying down, sitting, no movement, sleeping, no contact or interaction with conspecifics
Groom	Autogroom; biting, licking, scratching
Feed/Forage	Ingesting food; eating, drinking, looking for food; head in contact with the ground, uncovering or searching for a food item.
Locomotion	Any movement from one location to another; walking, running, climbing
Affiliative	A positive social behaviour; allo-grooming; huddled or basking together; play
Agonistic	A negative social behaviour; biting, scratching, chasing a conspecific
Not visible	Out of sight (including hut)
Children's groups	
Behaviour	**Definition**
Feed	Any attempt to feed an item of food
Touch	Any attempt to make physical contact in a non-aggressive way such as touching, petting or lifting
Chase/kick/throw	Any attempt to make contact in a more aggressive way; including chasing, kicking or throwing any object at a lemur.
Shout	A raised voice loud vocalisation directed at the lemurs

Table 7.5 Continued. Ethograms for the animal and children's behaviour observed at the three study sites.

B. Humboldt penguins at Fota Wildlife Park	
Behaviour	**Definition**
Pool - use	Any activity that took place in the penguins' pool; swimming, preening, standing at edge of water.
Vocalisation	Any vocalisation
Children's groups	
Behaviour	**Definition**
Feed	Any attempt to feed and item of food
Touch	Any attempt to make physical contact in a non-aggressive way such as touching, petting or lifting
Chase/kick/throw	Any attempt to make contact in a more aggressive way; including chasing, kicking or throwing any object at a penguin.
Climb	Climbing the enclosure wall/fence and standing over the penguins
Shout	A raised voice; a loud vocalisation directed at the penguins

Table 7.5 Continued. Ethograms for the animal and children's behaviour observed at the three study sites.

C. Gentoo penguins at Dingle Aquarium	
Behaviour	**Definition**
Surface swimming	Swimming on the surface of the water
Under water swimming	Swimming under water
Preening in Pool	Preening (see definition below) in the water
Porpoising	Jumping in an out of the water in typical penguin style
Inactive	Individual is not in the pool and is; sitting, sleeping, standing, the absence of any other behaviour
Preening	Feather maintenance, scratching, shaking
Locomotion	Movement on land; walking, hopping, running
Affiliative	Positive social behaviour with another penguin; allo-preening, bowing
Agonistic	Negative social behaviour with another penguin; staring, beaking, attacking
Attention to enrichment	Playing with, chasing or manipulating an enrichment device
Attention to visitors	Attempting to engage in some type of interaction with a visitor such as, tapping glass with beak, following in water, actively staring at a visitor through the glass wall
Nest behaviour	Engaged in any type of behaviour involving the nest such as, moving stones or sitting on the nest
Other	An unusual occurrence, any behaviour not listed above
Children's groups	
Behaviour	**Definition**
Bang	Banging on the glass with a hand or other object
Flash	Using flash photography
Climb	Climbing the artificial rock structures and standing over the penguins
Shout*	A raised voice; a loud vocalisation directed at the penguins

*****Although the glass is sound-proofed, this behaviour was included as it is not compliant with aquarium rules.

At Fota, in order to facilitate the children's groups meeting the free-ranging primates, the lemurs were called by Fota staff and received a small scatter feed of fruit next to the lemurs' hut (Figure 7.1). In the case of treatment groups, this was introduced as the fruit they had prepared during the EI. Some observations were discounted from this part of the research, if they did not follow the set parameters of the study, such as if the lemurs would not come down from the trees (see Appendix 2). This reduced the number of valid lemur-child observation sessions from 30 to 22. At each one-minute interval, the research assistant recorded the number of individual lemurs engaged in a specific behaviour (Table 7.5A). These values were then summed and divided by the length of the session in minutes to give the mean number of individuals engaged in each behaviour per minute of each observation session. At the same time, the primary researcher counted the total number of negative children's behaviours per observation period. This was divided by the length of the observation period in minutes to give the rate of negative behaviour per minute for each observation period. This recording procedure was also followed for the groups of children and Gentoo penguins at Dingle Aquarium (Table 7.5 C).

For the Humboldt penguin group at Fota Wildlife Park, the recording procedure differed slightly. It was not possible to observe a range of behaviours with this group of penguins because there were too many penguins to accurately count which birds were engaged in which behaviours in a short period of time. Therefore, pool use and vocalisation were chosen as behavioural measures for this group (Table 2B). The mean proportion of penguins in the pool per minute was calculated for each session, because both the session length and the number of penguins in the group varied considerably throughout the project. The total number of penguin vocalisations were counted for each observation period and then divided by the total observation time to give the rate of penguin vocalisations for each observation session. In order to minimise other variables of the zoo setting and produce as homogeneous a dataset as possible, certain data were excluded from the original dataset. For example, observations that occurred when the weather was poor were discounted, as previous research on this group of penguins suggests that they swim more when it rains (Foley, 2006). Observations that were recorded at the end of October, which was considered out of the breeding and rearing season, when the animals' behaviour may have changed, were also excluded (see Appendix 2). Children's behaviour was recorded as previously described (Table 7.5 B).

For both penguin species, if they were viewed by a treatment group, the enrichment made by the children during the EI was introduced at the beginning of the observation period. Though it was not a primary aim of this section of the research, when enrichment was introduced to the penguins, it was considered if pool use increased. First, a bubble machine was positioned at the edge of the enclosure near the water; the length of time the bubbles were blown for was determined by staff, but it was approximately 1-2 minutes. Then, the second enrichment device, five plastic bottles filled with shiny paper and sequins, were put into the water (Clarke, 2003). These enrichment devices were used because it was easy for the children to make them during the EI, and penguins are known to be attracted to shiny objects which provide foraging opportunities (G. Meechan RZSS Edinburgh Zoo, pers. comm., April 18, 2015). At Dingle Aquarium only the plastic bottles were used.

Data analysis

All data were tested for normality using the Kolmogorov-Smirnov test, and visually inspected with histograms and quantile-quantile plots. The Spearman rank-order correlation test and Kendall's coefficient of concordance were used to measure inter- and intra-observer reliability; a correlation of 0.7 or greater was considered acceptable (Martin and Bateson, 2007; Meagher, 2009).

First, the effect of participation in a control or treatment group (condition) on the rate of children's negative behaviour was assessed. Ideally, the effect of other independent variables such as age, gender, number of children in the group, 'stay time' (how long they viewed the animals) and a tour or camp experience would also have been analysed. However, while group composition did differ slightly, the variance of each independent variable was small (Tables 7.2–7.4). For example, school tour stay time ranged from 3-12 minutes (mean 6.38) and camp group stay time ranged from 3-12 minutes (mean 5.35). School tour groups (n=38) ranged in size from 15 to 40 children (mean 25.39), while camps (n=11) ranged in size from 5 to 32 children (mean 15.26). Therefore, because of small sample sizes, non-normality of data and little variation within each independent variable, it was decided to use the Mann-Whitney U test to analyse the effect of the main independent variable (condition) on the children's behaviour.

Next, for the animal behaviour, although some of the sample sizes are small and/or data violated some of the assumptions of normality, it was considered essential to evaluate the data in such a way as to use both condition (categorical: control or treatment group present) and the rate of negative behaviour (continuous) as independent variables and evaluate their effect on the dependent variables examined (Table 7.6). Independent variables were tested for multicollinearity and were found to be below the variance inflation factor (VIF) tolerance level of 1.5 in all cases. Behavioural diversity (BD) was considered an appropriate indicator of welfare for the ring-tailed lemurs and the Gentoo penguins (see Chapters 3 and 4 of this thesis). The mean BD level was calculated using the Shannon-Weaver diversity index H (Shannon & Weaver, 1949) for each observation period and used as the dependent variable in the analysis. For a full description of the methodology involving BD see Collins et al. (2016).

Finally, individual lemur and Gentoo penguin behaviours were examined when either a negative behaviour occurred or during the two test conditions. The use of a G-test was considered here, but since the data were recorded as rate data, the G-test was not applicable and individual Mann-Whitney U tests were used instead. All data were organised and analysed using IBM SPSS Statistics Version 22 and Microsoft Excel 2007. The accepted alpha level for these analyses was $p<0.05$ unless otherwise stated, and all tests are two-tailed. In this chapter, a discussion follows each section of results (children's behaviour, ring-tailed lemur behaviour, Humboldt penguin behaviour and Gentoo penguin behaviour) and is followed by a general discussion.

Table 7.6. Details of observations, dependent and independent variables investigated for each animal species studied.

Study site	Species	Total no. of observations	Dependent variables	Independent variables
Fota	1) Ring-tailed lemurs	22	Behavioural diversity	1) Rate of children's negative behaviour 2) Condition=control or treatment group 3) Length of observation session
Fota	2) Humboldt penguins	39	1) Pool use 2) Vocalisation	1) Rate of children's negative behaviour 2) Condition=control or treatment group 3) Length of observation session
Dingle	1) Gentoo penguins	13	Behavioural diversity	1) Rate of children's negative behaviour 2) Condition=control or treatment group

7.3 Results and discussion

7.3.1 Children's behaviour results and discussion

The Spearman rank-order correlation test showed that a mean of 0.92 (a strong positive association on a scale from -1 to +1) was maintained for inter-observer reliability testing between the researcher and staff during this part of the study (Appendix, Table A1 of this chapter). Plotted histograms and the Kolmogorov-Smirnov test revealed that behaviour data at Fota were non-normally distributed (children's behaviour at lemurs $p=0.002$; children's behaviour at penguins $p=0.006$; p-values are significantly different from normal). Although the rate of negative children's behaviour at Dingle followed a normal distribution ($p=0.200$), non-parametric statistics were used because of the small sample size. Statistically significant differences were found for the rate of children's negative behaviour between control and treatment groups at all three study species' enclosures.

Control groups, who did not participate in the EI, were significantly more likely to engage in negative behaviour at each exhibit (Table 7.7 and Figure 7.4).

Table 7.7. Results of the Mann-Whitney U test for the rate of children's negative behaviour between control and treatment groups while viewing each species included in the study.

Study site	**Species**	**Condition** **Mean ± SE**	**Test results**		
Fota Wildlife Park	Ring-tailed lemurs	Control 0.24 ± 0.06 Treatment 0.03 + 0.03	n=16,6	U=18.00	p=0.020
Fota Wildlife Park	Humboldt penguins	Control 0.61 ± 0.10 Treatment 0.14 + 0.05	n=24,15	U=36.50	p < 0.001
Dingle Aquarium	Gentoo penguins	Control 1.13 ± 0.18 Treatment 0.53 + 0.09	n=7,6	U=6.00	p=0.031

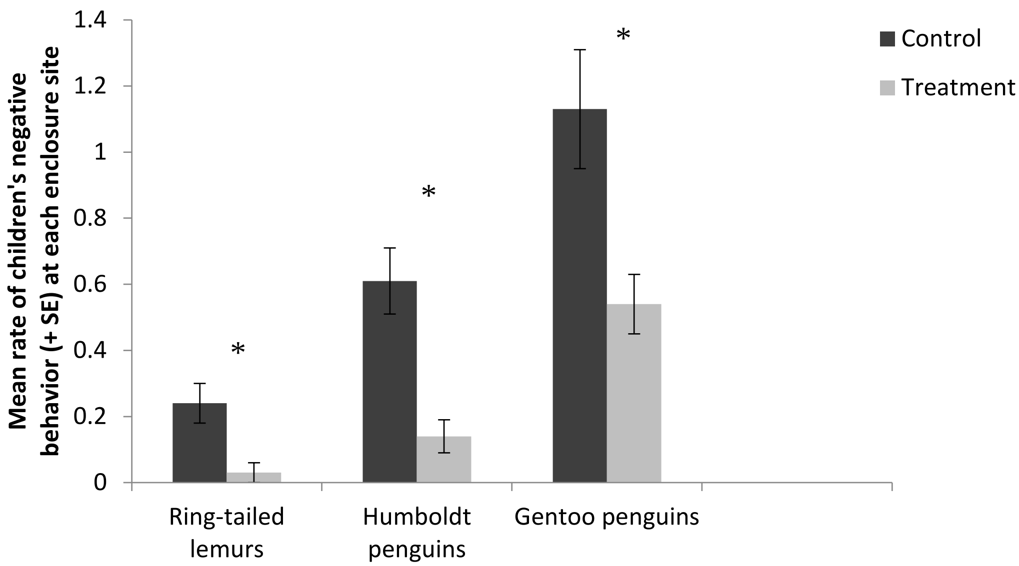


Figure 7.4. The rate of children's negative behaviour at each study species enclosure site during control and treatment conditions. *denotes statistically significant difference.

Orams and Hill (1998, p.38) state that 'a formal, structured education program can be a mechanism by which compliance with management strategies can be increased' in regards to environmentally responsible behaviour. The results found here support that statement.

Similar to the recent study by Sherwen et al. (2014), which used signage in an attempt to reduce visitor noise and thus improve meerkat welfare, the current research found that in all cases children in treatment groups engaged in fewer negative behaviours towards captive animals. The current research, together with Bexell et al. (2013), has demonstrated that it is possible to observe and record on-site behaviour in the zoo setting. The data did not allow for other variables that might have affected children's behaviour, such as age or gender, to be accounted for. This could be an area for future research so that zoo staff would be aware that certain groups may be more inclined to direct negative behaviours at the animals.

7.3.2 Fota Wildlife Park – Ring-tailed lemurs results and discussion

The Spearman rank-order correlation revealed that a mean of 0.91 was maintained for inter-observer reliability between the primary researcher and the research assistants throughout the project with values ranging from 0.82 to 1.00 (Appendix, Table A2 of this chapter). Intra-observer reliability testing also showed a strong correlation with a mean level of 0.94 achieved during the study (Appendix, Table A3 of this chapter).

Testing for normality indicated that behavioural diversity data are approximately normally distributed ($p=0.101$). First, a general linear model (GLM) was conducted to test the significance of three independent variables (rate of children's negative behaviour [covariate], length of session [covariate] and experimental condition [fixed factor]) on behavioural diversity level. A backwards stepwise procedure was used to remove the non-significant factors from the model (Appendix, Table A4 of this chapter). Validation for the model was conducted for each model by plotting a histogram of residuals, plotting residuals against predicted values and checking the linearity of the models. This resulted in a final model with the rate of children's negative behaviour as the only remaining explanatory variable. Although this was not statistically significant ($F= 3.241$; $p=0.087$), the trend observed was a negative association between high levels of negative children's behaviour and decreased behavioural diversity levels in ring-tailed lemurs (Figure 7.5).

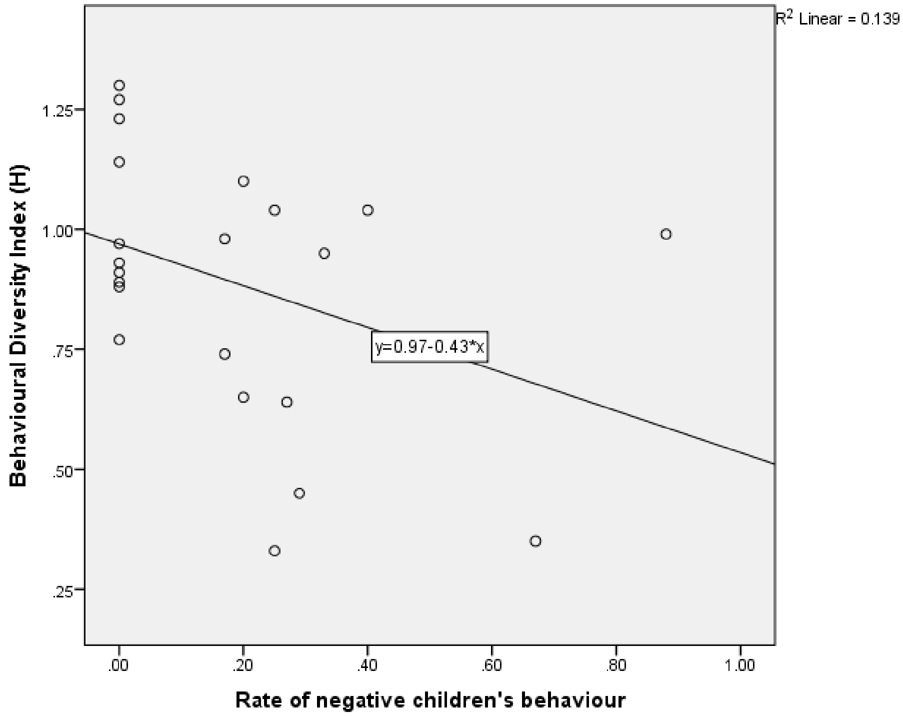


Figure 7.5. Behavioural diversity index (H) versus the rate of children's negative behaviour with regression line for ring-tailed lemur data.

Next, to explore the effect of negative children's behaviour on specific lemur behaviours, the rate of negative behaviour was changed to a categorical variable: a negative behaviour occurred (n=12) or did not occur (n=10). Here, the Mann-Whitney U test was used (Table 7.8). The only lemur behaviour that was found to be significantly affected by children's behaviour was locomotion, with fewer lemurs observed in locomotion during sessions when a child's negative behaviour occurred (Figure 7.6). Also, data indicate that 'not visible' was the most frequently observed behaviour during both conditions. Though it appears that more lemurs were not visible when a negative behaviour occurred, this finding is not statistically significant. Additionally, feeding decreased slightly when children engaged in negative behaviour, but again this did not reach statistical significance. Inactive, grooming, affiliative and agonistic are difficult to interpret because of small numbers of lemurs engaged in these behaviours, but no statistically significant differences were detected (Figure 7.6).

Table 7.8. Results of the Mann-Whitney U test for specific lemur behaviours during observation sessions with and without negative children's behaviour at Fota Wildlife Park.

Behaviours	U	p
Inactive	59.00	0.947
Groom	52.50	0.597
Feed	38.50	0.155
Locomotion	25.50	0.023
Affiliative	57.00	0.740
Agonistic	48.00	0.113
Not visible	43.50	0.276

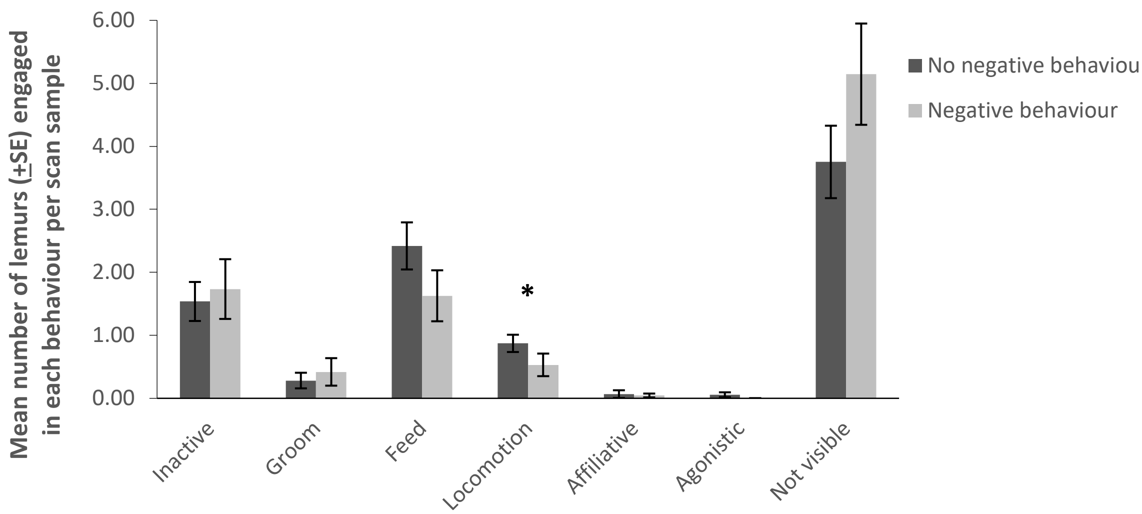


Figure 7.6. The mean number of lemurs engaged in specific behaviours during periods with and without incidences of negative behaviour from children at Fota Wildlife Park. *denotes statistically significant difference.

The current study found no statistically significant effect of the presence of either the control or treatment group on the lemurs' behavioural diversity level. However, there was an indication that the lemurs' behavioural diversity level decreased when children's negative behaviour increased. This suggests that fewer lemurs engaged in fewer behaviours, when negative visitor behaviour occurred. A closer examination of individual lemur behaviours during observation sessions with and without negative behaviour revealed that more lemurs were not visible when negative behaviours occurred, which would also account for the lower level of behavioural diversity. It should be noted that the data do not reflect when the lemurs became ‘not visible;’ they may not have been visible before the groups of children arrived. Conversely, during observation session when no negative visitor behaviours occurred, more lemurs were observed feeding and in locomotion, which was the only statistically significant finding for this section of the study, though it may be that as more lemurs were visible other behaviours inevitably increased. Because of the findings of Luebke et al. (2016), it should be considered that when fewer animal behaviours were observed, perhaps the visitors did not feel a positive emotional connection to the animals and their behaviour towards them was poor.

Interestingly, earlier research with this group of lemurs (Collins et al., 2017 and Chapter 3 of this thesis) found no effect of negative visitor behaviour on any observed lemur behaviour. It is possible that in the current study the frequency of negative visitor behaviour with groups of children was more intense, sometimes with several negative behaviours occurring during a short period, leading to a reduction of lemur locomotion and behavioural diversity level. Collins et al. (2017) detected an increase in locomotion as visitor number increased, which the authors attribute to visitors being attracted to active animals. Therefore, results on locomotion from this section of the study suggest that it is the behaviour of visitors and not the number of visitors that might bother lemurs. Collins et al. (2017) also found an indication that high visitor numbers over the course of the day might lead to a reduction in behavioural diversity level. Here, a possible link between reduced behavioural diversity and negative behaviour was found. Therefore, it seems possible that large numbers of visitors behaving poorly over the course of several hours could lead to a reduction in behavioural diversity and possibly welfare. This research shows the importance of teasing out differences between visitor number and visitor behaviour (both instantaneous and cumulative) on animals’ behaviour, perhaps focusing on treatment and control days rather than groups should be an area of further research.

7.3.3 Fota Wildlife Park – Humboldt penguins results and discussion

The data followed a non-normal distribution ($p<0.001$, for both behaviours). Both the Arcsine square-root transformation and Logit transformation were considered for this dataset; however, the transformations were not successful and the original non-transformed dataset was used for all analysis. Although the data did not follow a normal distribution, the sample size was considered large enough to test using a GLM. Because a statistical test was applied to a dataset that violated some of the assumptions of the test, the accepted alpha level for this section was $p<0.01$, in order to avoid making a Type I error (Plowman, 2008). The same analysis procedure as was described for the lemurs was applied for the Humboldt penguins.

For pool use, neither the length of the session ($F=0.109$; $p=0.743$), experimental condition ($F=2.002$; $p=0.166$) nor the rate of negative behaviour ($F=2.791$; $p=0.103$) was statistically significant, meaning that none of the explanatory variables affected penguins' pool use (Appendix, Table A5 of this chapter). Vocalisation resulted in a final model with condition and length of session as the remaining explanatory variables (Appendix, Table A6 of this chapter). In this case they were statistically significant (condition: $F=121.297$; $p<0.001$; length of session: $F=12.941$, $p<0.01$), with more vocalisations occurring when treatment groups were present and as the length of the session increased (Figure 7.7 and 7.8).

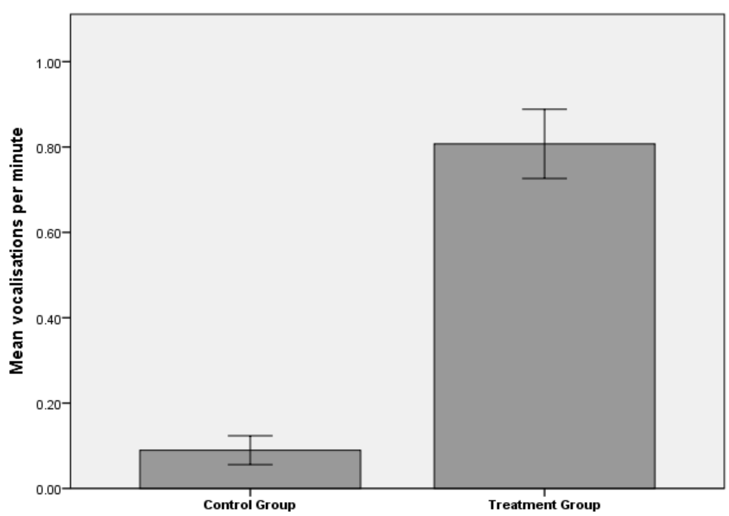


Figure 7.7. Mean penguin vocalisations per minute observed with control or treatment groups present (± SE) at Fota Wildlife Park.

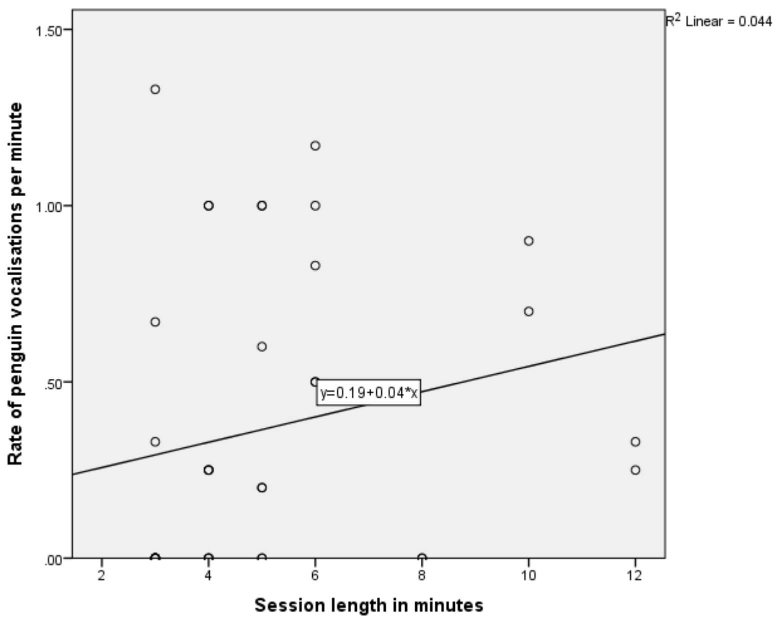


Figure 7.8. The rate of penguin vocalisations per minute versus the length of the observation session at Fota Wildlife Park.

There has been minimal research conducted on how penguins react to visitors. Research on wild penguins offers ambiguous results on the effect of human presence on penguin behaviour (Wilson et al., 1991; Cobley and Shears, 2002). However, studies from captive populations indicate little effect of visitors on penguins' behaviour (Ozella et al., 2015; Collins et al., 2016). However, because of the open exhibit design at Fota Wildlife Park, the Humboldt penguins can be subjected to intense visitor behaviour, such as feeding, touching and throwing objects.

Pool use has previously been used as an indicator of penguin welfare (Larsson, 2012; Collins et al., 2016), and the current research also sought to encourage penguin pool use by introducing enrichment made by children. However, penguins' pool use was not affected by any condition that was tested. This result confirms the result of Collins et al. (2016) that captive penguins are unlikely to give a behavioural response to the presence of enrichment or negative behaviour from visitors. However, the penguins at Fota were more likely to vocalise when the treatment group was present. While it is possible that there was some nuance of the treatment groups that did not occur with the control groups, the more likely explanation for the increase in vocalisation is due to the presence of enrichment.

Previous research has outlined the vocal repertoire of captive penguins (*Spheniscus* spp.) (Thumser and Ficken, 1998; Favaro et al., 2014), and an increase in vocalisation could be an indication of increased socialisation (Thumser et al., 1996; Reiss-Woolever, 2017). However, researchers in the current study were not trained to recognise the different calls given by the penguins. In the absence of any other observed behavioural indicator, the increased vocalisation was interpreted as an indication of curiosity or excitement, but this could be an area of further research. The penguins also vocalised more the longer the group remained. The reason for this is unclear, but it could indicate that the novelty of the enrichment did not diminish during the course of the observation session and perhaps interest increased as more penguins became aware of the presence of the devices. Other than the increase in vocalisation, the penguins showed little interest in the enrichment device, which is similar to the findings of previous research on this penguin group (Dunne, 2015). However, both Dunne (2015) and the current research observed the penguins around the breeding season, which may have affected results. For example, penguins are more likely to vocalise during the breeding season (S. McKeown, Director of FWP, August, 2018). Future work with this penguin group should focus on periods outside the breeding and rearing stages to assess if penguins' interest in enrichment differs then. Additionally, due to different animal personalities individuals may give a different behavioural response to enrichment devices (Makecha and Highfill, 2018), and here the group rather than individuals were observed. Future research could consider individual penguin's responses to enrichment.

While the penguins showed little interest in the enrichment device and pool use did not increase, there were no indications that the penguins were disturbed by the visitors, even when they engaged in negative behaviour. This gives further evidence that penguins are a suitable species to engage the public (Collins et al., 2016). As a caveat, it should not be overlooked that subtle physiological indicators of stress may have occurred that were not detected here. It has previously been reported that penguins show little behavioural response to humans, but they may react with a physiological response such as increased heart rate (Carney and Sydeman, 1999). Physiological monitoring of this group of penguins should be considered in future research since several previous research studies have found little behavioural response from them (Dunne, 2015).

Limitations occurred during this part of the study. In addition to pool use, it would have been better to include other penguin behaviours so that behavioural diversity level could be analysed, but because of the large numbers of penguins, which were not possible to identify even by gender, this was not feasible. Also, it is possible that some of the penguins may have been moulting during the later period of data collection at Fota, making pool use unlikely for these birds; however, this was not observed by the researcher.

7.3.4 Dingle Aquarium – Gentoo penguins results and discussion

A high level of inter-observer reliability was attained (W=0.900, p=0.019) and (r_s=0.918; p=0.028) throughout the study. The Kolmogorov-Smirnov test indicated that behavioural diversity data did not follow a normal distribution (p=0.034), and the sample size was considered too small to apply a GLM. Therefore, non-parametric statistics were used. It was not possible to avoid multiple comparisons on this dataset, if both independent variables were to be included in the analysis. Therefore, the accepted alpha level was reduced to 0.01 (Plowman, 2008; Quirke, 2011), and session length as an independent variable was excluded.

The Mann-Whitney U test showed no difference in the penguins' behavioural diversity level between treatment or control groups (U=16.00, p=0.475). Nor was there an association between the penguins' behavioural diversity level and the rate of children's negative behaviour detected using the Spearman rank correlation test (r_s =-0.102; p=0.739).

During this part of the study a negative behaviour was observed during each observation period, making it impossible to investigate negative behaviour as a categorical variable on the penguins' activity budget. Therefore, specific penguin behaviours were examined in relation to the presence of the control or treatment groups using the Mann Whitney U-test (Table 7.9). Attention to visitors was the only penguin behaviour found to be statistically significant; the penguins paid more attention to visitors when the treatment group and enrichment were present than when the control groups with no enrichment were present (Figure 7.9). Inactivity also appeared to increase with the treatment group, but this was not found to be statistically significant. Nesting, which was the most frequently observed behaviour, and preening decreased slightly when the treatment group was present; however, these did not reach statistical significance. Pool use was not affected by the presence of the control or treatment group, indicating that the introduced enrichment had no effect on this behaviour. Locomotion, affiliative, agonistic and other were similar during the two conditions, but low levels of occurrence make interpretation difficult and no statistically significant differences occurred (Figure 7.9).

Table 7.9. Results of the Mann-Whitney U test for specific penguin behaviours with control and treatment groups present at Dingle Aquarium.

Behaviours	U	p
Pool Use	20.00	0.886
Inactive	13.00	0.253
Preen	17.00	0.564
Locomotion	20.50	0.943
Affiliative	14.00	0.277
Agonistic	14.00	0.290
Visitor Attention	5.00	0.020
Nest	14.00	0.317
Other	18.00	0.355

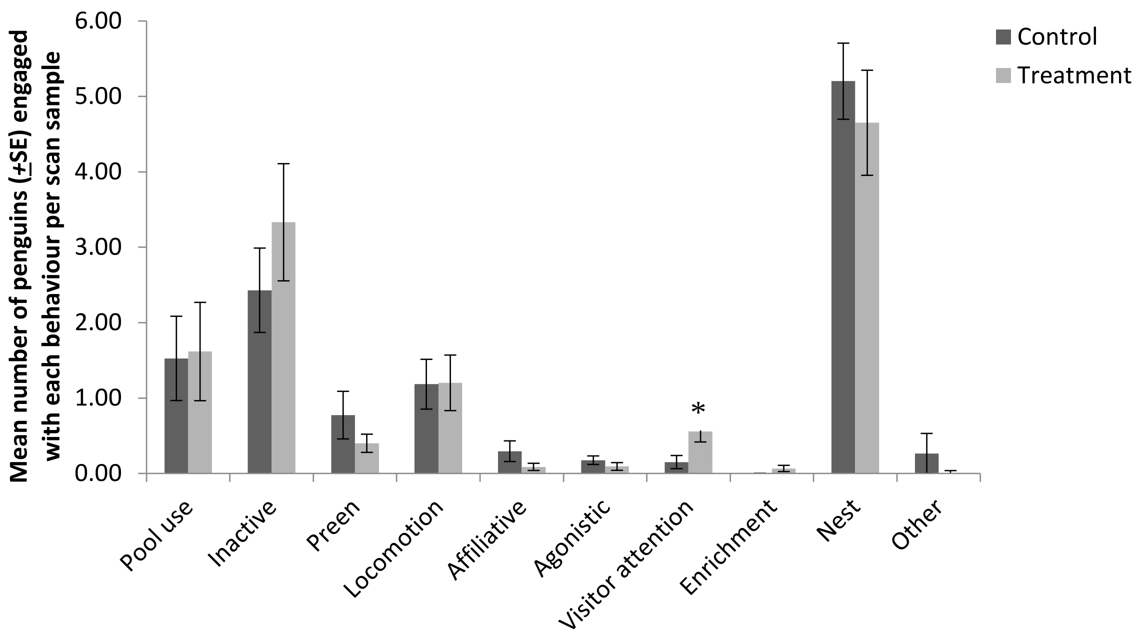


Figure 7.9. Mean number of penguins engaged in each of the listed behaviours with control and treatment groups present at Dingle Aquarium. *denotes statistically significant difference.

Previous research on the penguin group at Dingle Aquarium found that generally the penguins were not affected by enrichment or visitors, even those that engaged in negative behaviour (Collins et al., 2016). However, the penguins' welfare is a primary concern, and despite signs and staff presence groups of school children are known to bang the glass, use flash photography and climb the structures surrounding the enclosure. This part of the research sought to control visitor behaviour and improve penguin welfare through an educational intervention; however, despite receiving the most negative behaviour of any species in the study (Table 7.7), results indicated that, the penguins' behavioural diversity level was not affected by the presence of control or treatment groups or by children's behaviour.

When individual penguin behaviours were examined with control and treatment groups present, it was discovered that the treatment groups (with enrichment) coincided with an increase in inactivity and attention to visitors and a decrease in nesting and preening. These findings may be associated with the presence of enrichment, though it is unclear since previous research with this group did not find a reduction in nesting when enrichment was present (Collins et al., 2016). It is more likely that the visiting children were more animated because of the enrichment and this attracted the penguins' attention. Results show that the rate of negative children's behaviour was reduced for the treatment group, but there could have been an increase in behaviours that were not considered negative, such as proximity to the glass or arm waving, that attracted the penguins' attention. The implications of this are unclear, but a reduction in nesting might be a cause for concern and area for further investigation. These findings illustrate the importance of thoughtfully categorising visitor behaviour. It is possible that what a researcher identifies as a positive or negative viewing behaviour from the public is different from what captive animals perceive.

7.4 General discussion

Luebke et al. (2016) suggested that behaviours from visitors that are often deemed inappropriate such as banging on glass may be the visitors way of establishing a connection or provoking a response from animals and it is not necessarily intended to be insensitive. However, it is the zoos responsibility to provide visitors with the experiences they seek, while maintaining a high standard of animal welfare. Supervised, hands-on, up-close animal experiences with a strong educational message with species that are known not to be disturbed by visitors, may be a way for zoos to balance these requirements.

Several studies have successfully reduced negative visitor behaviour while viewing animals by introducing educational material (Kratochvil and Schwammer, 1997; Orams and Hill, 1998; Bexell et al., 2013; Sherwen et al., 2014), and the results from the current study support these findings. Since it is generally predicted that negative behaviour from visitors towards animals could negatively impact an animal's welfare, it is reasonable to predict that a reduction in negative visitor behaviour should lead to improved animal welfare. However, it has proved more difficult to show this connection. Both Sherwen et al. (2014) and the current study did find a reduction in negative visitor behaviour with the introduction of educational material, but this did not lead to any discernible behavioural response from the animals that were observed in either study. It is possible that the animals observed were not affected by visitor behaviour so that any variation in it does not lead to a noticeable behavioural response (Sherwen et al., 2014), or that repeated exposure has led to habituation (Hosey, 2013). However, it is also possible that there is a cumulative effect of negative visitor behaviour and that a behavioural response is only detectable after multiple encounters with badly behaved groups. Equally, the animals may give a physiological response that is not detectable through observation. Future research in this area should perhaps focus on animals definitively known to suffer from reduced welfare, as a consequence of visitor behaviour, so that any effects of an applied treatment are easier to detect. Additionally, it was not possible to separate observations with enrichment from groups that had received the educational intervention. It would have been more suitable to observe this separately so any observed effect could be directly related to one condition; however, due to scheduling and time constraints this was not possible. The scatter feed was also present for both control and treatment groups that viewed the lemurs, however there was no other way to ensure that the children would meet the lemurs.

Regardless, there was a significant reduction in negative behaviour towards the animals at all three exhibits, when a group that experienced the EI was present. Bexell et al. (2013), who found similar results, state that the decrease in negative behaviour towards animals is indicative of an increase in cognitive empathy. This may lead to pro-conservation behaviour or environmental stewardship (Bexell et al., 2013). Thus, one of the goals of environmental education as outlined by the 1977 Tbilisi Declaration (UNESCO, 1978) and the 1990 UN sponsored conference 'World Conference on Education for All – Meeting Basic Learner Needs,' promoting positive environmental behaviour change, has been achieved (Hungerford and Volk, 1990). Educational material aimed at promoting empathy towards animals and pro-conservation behaviour, may be beneficial for increasing the efficacy of zoo education programmes.

7.5 Conclusions

1. The educational intervention was successful at reducing negative behaviour from children towards all three species of captive animal and both institutions.
2. A slight decrease in ring-tailed lemurs' behavioural diversity level occurred, as the rate of children's negative behaviour increased, though this was not statistically significant.
3. The Humboldt penguins at Fota Wildlife Park vocalised more when the treatment group was present, which was probably attributable to the presence of enrichment.
4. The Gentoo penguins at Dingle Aquarium, appeared largely unaffected by the presence of treatment or control groups or negative behaviour from children.

7.6 References

Altmann, J. (1974). Observational study of behavior: sampling methods. *Behaviour*, 49(3), 227-266.

Altman, J. D. (1998). Animal activity and visitor learning at the zoo. *Anthrozoös*, 11(1), 12-21.

Bexell, S. (2006). Effect of a Wildlife Conservation Camp Experience in China on Student Knowledge of Animals, Care, Propensity for Environmental Stewardship, and Compassionate Behavior Toward Animals. PhD Dissertation, Georgia State University.

Bexell, S. M., Jarrett, O. S. & Ping, X. (2013). The effects of a summer camp program in China on children's knowledge, attitudes, and behaviors toward animals: A model for conservation education. *Visitor Studies*, 16(1), 59-81.

Birke, L. (2002). Effects of browse, human visitors, and noise on the behaviour of captive orang-utans. *Animal Welfare*, 11, 189-202.

Blaney, E. C. & Wells, D. L. (2004). The influence of a camouflage net barrier on the behaviour, welfare and public perceptions of zoo-housed gorillas. *Animal Welfare,* 13(2), 111-118.

Carney, K. M. & Sydeman, W. J. (1999) A review of human disturbance effects on nesting colonial waterbirds. *Waterbirds*, 68-79.

Choo, Y., Todd, P. A. & Li, D. (2011). Visitor effects on zoo orangutans in two novel, naturalistic enclosures. *Applied Animal Behaviour Science*, 133(1), 78-86.

Clarke, A. G. (2003) Factors affecting pool use by captive Humboldt penguins (*Spheniscus humboldti*). In *Proceedings of the 5th Annual Symposium on Zoo Research*, Marwell Zoological Park, Winchester, UK, 7-8th July 2003. (pp. 190-204). Federation of Zoological Gardens of Great Britain and Ireland.

Cobley, N. D. & Shears, J. R. (1999) Breeding performance of Gentoo penguins (*Pygoscelis papua*) at a colony exposed to high levels of human disturbance. *Polar Biology*, 21(6), 355-360.

Collins, C. K. & Marples, N. M. (2015). Zoo playgrounds: A source of enrichment or stress for a group of nearby cockatoos? A case study. *Journal of Applied Animal Welfare Science*, 18(4), 375-387.

Collins, C. K., Quirke, T., Overy, L., Flannery, K. & O'Riordan, R. (2016). The effect of the zoo setting on the behavioural diversity of captive gentoo penguins and the implications for their educational potential. *Journal of Zoo and Aquarium Research*, 4(2), 85-90.

Collins, C., Corkery, I., Haigh, A., McKeown, S., Quirke, T. & O'Riordan, R. (2017). The effects of environmental and visitor variables on the behavior of free-ranging ring-tailed lemurs (*Lemur catta*) in captivity. *Zoo Biology*, 36(4), 250-260.

Dunne, C. (2015). Environmental Enrichment for Captive Humboldt Penguins (*Spheniscus humboldti*). Final year report. University College Cork, Ireland.

Favaro, L., Ozella, L. & Pessani, D. (2014). The vocal repertoire of the African Penguin (*Spheniscus demersus*): structure and function of calls. *PloS one*, 9(7), e103460.

Fernandez, E. J., Tamborski, M. A., Pickens, S. R. & Timberlake, W. (2009). Animal-visitor interaction in the modern zoo: conflicts and interventions. *Applied Animal Behaviour Science*, 120, 1-8.

Foley, L. (2006). The Behaviour of a group of captive Humboldt penguins (*Sphenicus humboldti*) at Fota Wildlife Park. Final year report. University College Cork, Ireland.

Hosey, G. (2013). Hediger revisited: how do zoo animals see us? *Journal of Applied Animal Welfare Science*, 16(4), 338-359.

Hungerford, H. R. & Volk, T. L. (1990). Changing learner behavior through environmental education. *The Journal of Environmental Education*, *21*(3), 8-21.

Jensen, E. (2011). *Learning about Animals, Science and Conservation at the Zoo: Large-scale survey- based evaluation of the educational impact of the ZSL London Zoo Formal Learning programme*. A report to The Zoological Society of London.

Jensen, E. (2014). Evaluating children's conservation biology learning at the zoo. *Conservation Biology*, 28(4), 1004-1011.

Keane, C. W. (2005). The effects of zoo visitors on the behaviour of Western Lowland gorillas (*Gorilla gorilla gorilla*), Citron-Crested (*Cacatua sulphurea citrinocristata*) and Moluccan Cockatoos (*Cacatua moluccensis*). MSc. thesis, Trinity College, University of Dublin, Ireland.

Kratochvil, H. & Schwammer, H. (1997). Reducing acoustic disturbances by aquarium visitors. *Zoo Biology*, 16, 349-353.

Kuhar, C. W., Bettinger, T. L., Lenhardt, K., Tracy, O. & Cox, D. (2010). Evaluating for long-term impact of an Environmental Education Program at the Kalinzu Forest Reserve, Uganda. *American Journal of Primatology*, 72, 407-413.

Larsson, A. (2012) Development and evaluation of environmental enrichment for captive Humboldt penguins. Swedish University of Agricultural Sciences, Department of Animal, Environment and Health Ethology and Animal Welfare programme. Student Report 443.

Luebke, J. F., Watters, J. V., Packer, J., Miller, L. J. & Powell, D. M. (2016). Zoo Visitors' Affective Responses to Observing Animal Behaviors. *Visitor Studies*, 19(1), 60-76.

Makecha, R. N. & Highfill, L. E. (2018). Environmental enrichment, marine mammals, and animal welfare: A brief review. *Aquatic Mammals*, 44(2), 221-230.

Mallapur, A. & Chellam, R. (2002). Environmental influences on stereotypy and the activity budget of Indian leopards (*Panthera pardus*) in four zoos in southern India. *Zoo Biology*, 21(6), 585-595.

Martin, P. & Bateson, P. (2007). *Measuring behaviour: an introductory guide*. Cambridge University Press.

Meagher, R. K. (2009). Observer ratings: validity and value as a tool for animal welfare research. *Applied Animal Behaviour Science*, 119(1), 1-14.

Morgan, K. N. & Tromborg, C. T. (2007). Sources of stress in captivity. *Applied Animal Behaviour Science*, 102(3), 262-302.

Myers Jr, O. E. & Saunders, C. D. (2002). Animals as links toward developing caring relationships with the natural world. *Children and nature: Psychological, sociocultural, and evolutionary investigations*, 153-178.

Nimon, A. J. & Dalziel, F. R. (1992). Cross-species interaction and communication: a study method applied to captive siamang (*Hylobates syndactylus*) and long-billed corella (*Cacatua tenuirostris*) contacts with humans. *Applied Animal Behaviour Science*, 33(2), 261-272.

Ogden, J. & Heimlich, J. E. (2009). Why focus on zoo and aquarium education? *Zoo Biology*, 28(5), 357–60.

Orams, M. B. & Hill, G. J. (1998). Controlling the ecotourist in a wild dolphin feeding program: is education the answer? *The Journal of Environmental Education*, 29(3), 33-38.

Ozella, L., Favaro, L., Carnovale, I. & Pessani, D. (2015). Pond Use by Captive African Penguins (*Spheniscus demersus*) in an Immersive Exhibit Adjacent to Human Bathers. *Journal of Applied Animal Welfare Science*, 18(3), 303-309.

Plowman, A. B. (2008). BIAZA statistics guidelines: toward a common application of statistical tests for zoo research. *Zoo Biology*, *27*(3), 226-233.

Quadros, S., Goulart, V. D., Passos, L., Vecci, M. A. & Young, R. J. (2014). Zoo visitor effect on mammal behaviour: Does noise matter? *Applied Animal Behaviour Science*, 156, 78-84.

Quirke, T. (2011) Cheetah Behaviour in Captivity and the Effects of Environmental Enrichment. PhD Thesis. University College Cork, Ireland.

Reiss-Woolever, V. (2017). The Effects of Feeding Regime on the Behaviour of Captive Humboldt Penguins (*Spheniscus humboldti*). Final year report. University College Cork, Ireland.

Sattler, J. M. (1988). *Assessment of children*. pp. 472-529. San Diego, CA.

Shannon, C. E. & Weaver, W. (1949) *The Mathematical Theory of Information.* University of Illinois Press, Urbana, IL.

Sherwen, S. L., Magrath, M. J., Butler, K. L., Phillips, C. J. & Hemsworth, P. H. (2014). A multi-enclosure study investigating the behavioural response of meerkats to zoo visitors. *Applied Animal Behaviour Science*, 156, 70-77.

Smith, L., Broad, S. & Weiler, B. (2008). A closer examination of the impact of zoo visits on visitor behaviour. *Journal of Sustainable Tourism*, 16(5), 544-562.

Stevens, J., Thyssen, A., Laevens, H. & Vervaecke, H. (2013). The influence of zoo visitor numbers on the behaviour of harbour seals (*Phoca vitulina*). *Journal of Zoo and Aquarium Research*, 1(1), 31-34.

Thumser, N. N., Karron, J. D. & Ficken, M. S. (1996). Interspecific variation in the calls of *Spheniscus* penguins. *The Wilson Bulletin*, 72-79.

Thumser, N. N. & Ficken, M. S. (1998). A comparison of the vocal repertoires of captive *Spheniscus* penguins. *Marine Ornithology*, 26, 41-48.

UNESCO. 1978. Final report: Intergovernmental Conference on Environmental Education, Organizedby UNESCO in Cooperation with UNEP, Tbilisi, USSR, October 14–26, 1977, Paris: UNESCO ED/MD/49.

Wilson, R. P., Culik, B., Danfeld, R. & Adelung, D. (1991). People in Antarctica - how much do Adélie Penguins (*Pygoscelis adeliae)* care? *Polar Biology*, 11(6), 363-370.

Wood, W. (1998). Interactions among environmental enrichment, viewing crowds, and zoo chimpanzees (*Pan troglodytes*). *Zoo Biology*, 17, 211-230.

Chapter 7: Appendix

Table A1: Results of Spearman's rank order correlation test between the researcher and staff at Fota and Dingle for children's behaviour at each animal enclosure. Where n is the number of observation sessions.

Site	n	r_s	*p*
Fota - Lemurs	22	1.00	<0.001
Fota - Penguins	39	0.93	<0.001
Dingle - Penguins	13	0.82	0.001

Table A2: Results of Spearman's rank order correlation test between the researcher and each research assistant at Fota Wildlife Park's lemur enclosure. Where n is the number of lemur behaviours recorded during one 5-minute observation session.

Research Assistant	n	r_s	*p*
1	6	1.00	<0.001
2	6	0.94	0.005
3	6	0.82	0.046
4	6	1.00	<0.001
5	6	0.85	0.034
6	6	0.95	0.003
7	6	0.83	0.04

Table A3: Results of Spearman's rank order correlation test when the researcher measured identical samples of lemur behaviour for intra-observer reliability testing. Where n is the number of lemur behaviours recorded during five observation sessions.

Session	N	r_s	*p*
1	6	0.95	0.003
2	6	1.00	<0.001
3	6	0.87	0.025
4	6	1.00	<0.001
5	6	0.88	0.019

A4. Models applied for ring-tailed lemur behavioural diversity level using GLMs.

Model	Independent variables	Description	Variables removed from the model, p-value
M1	Condition (control or treatment) + Length of session + Rate of Neg. Behaviour	All variables	Length of session, p=0.957
M2	Condition (control or treatment) + Rate of Neg. Behaviour	Children's variables	Condition, p=0.545
	Variable remaining in the model	**Description**	**p-value**
M3	Rate of Neg. Behaviour	Final Model	p=0.087

A5. Model applied for Humboldt penguins' pool use using a GLM.

Model	Independent variables	Description	Variables remaining in the model
M1	Condition (control or treatment) + Length of session + Rate of Neg. Behaviour	All variables	Length of session, p=0.743
	Variables remaining in the model	**Description**	**p-value**
M2	Condition (control or treatment) + Rate of Neg. Behaviour	Final Model	Condition, p=0.166; Neg. Behaviour, p=0.103

A6. Models applied for Humboldt penguins' vocalisation using GLMs.

Model	Independent variables	Description	Variables removed from the model, p-value
M1	Condition (control or treatment) + Rate of Neg. Behaviour	Children's variables	Rate of negative behaviour, p=0.899
	Variables remaining in the model	**Description**	**p-value**
M2	Condition (control or treatment) + length of session	Final Model	p < 0.001, p <0.01

Chapter 8

Conversational content analysis: an investigation of children's conversation in the zoo setting.

Abstract

The evaluation of learning in the zoo is a complex process with many influences affecting learning outcomes. Traditional methods of evaluating education may not consider all of the potential influences on learning in the zoo setting. One innovative and under-used technique for assessing learning is to listen to visitors' conversations as they view animals. Evaluating visitors' conversation allows the immediate response of visitors to animals to be discovered, as well as allowing for social influences, personal beliefs and the effect of the physical surroundings to be taken into consideration. The current chapter used conversation content analysis to investigate learning in the zoo and discovered that children engaged in diverse topics of conversation indicative of learning as they viewed animals. However, groups of children who experienced the purposefully developed educational intervention made more types of positive comments and fewer types of negative comments. Additionally, the species viewed affected the diversity of positive comments. Groups that viewed the ring-tailed lemurs (*Lemur catta*) and the Gentoo penguins (*Pygoscelis papua*) made more types of positive comments than those that viewed the Humboldt penguins (*Spheniscus humboldti*). The results indicate that visitors do learn in the zoo setting and that overheard conversation offers a unique insight into the visitors' experience at the zoo. Future research should build on the results presented here to more comprehensively study children's learning in the zoo using this methodology.

8.1 Introduction

Children visiting a zoo inevitably have a lot to talk about, much of it is social discourse, but some of their conversation will also include learning discourse (Patrick and Tunnicliffe, 2012). If educators learn to listen to visitors as they visit exhibits at the zoo, this can lead to an understanding of the knowledge that is acquired during the visit (Patrick and Tunnicliffe, 2012). Since education is a primary goal for most zoos (Patrick et al., 2007), conversational content analysis is a valuable tool for understanding learning in the zoo and may lead zoos to better understand how visitors view their exhibits (Tunnicliffe et al., 1997). Additionally, informal education is a complex process, which varies for each individual and is constructed based on personal experience, social interactions and physical surroundings (Falk and Dierking, 2000). Measuring learning in the zoo can be challenging and specific learning outcomes may not be immediately apparent or take into consideration the individual components of learning when measured with traditional methods, but the analysis of visitors' conversation allows for the examination of visitors' direct experience as they view animal exhibits (Clayton et al., 2009).

A limited amount of research involving conversation has previously taken place in museums and zoos (e.g. Tunnicliffe et al., 1997; Allen, 2002), and broadly it has been found that zoo exhibits with living animals generate complex learning, which draws on visitors' previous knowledge (Clayton et al., 2009). Overheard conversation can give meaningful insight, to both zoo educators and school teachers, about children's natural interests, which educators can then build upon to enhance learning (Tunnicliffe et al., 1997). However, when family and school groups' conversations at the zoo were compared, they were found to be very similar, except that school groups, particularly girls, made more affective and emotive comments than family groups (Tunnicliffe et al., 1997). The authors describe the similarities between groups as unexpected, assuming that schools visit for educational purposes and families for social reasons (Tunnicliffe et al., 1997). Although the study found that all visitors talked about exhibits and animals as they viewed them, the lack of conversation amongst school children that evidenced the scientific process (e.g. justification of comments; reconciliation between prediction and observation), even though they were visiting the zoo as part of their school curriculum, was concerning (Tunnicliffe et al., 1997). Tunnicliffe et al. (1997) concluded that schools are ‘missing’ an educational opportunity in that they are not fully using the educational potential of the zoo visit, but this could be rectified by thoughtful preparation and follow up discussion.

Clayton et al. (2009) investigated how personal connections to animals on exhibit relates to a general concern for animals. This was achieved through surveys, but also through 1,900 overheard conversations of zoo visitors. The authors stated that the analysis of conversation allows for the social aspect of learning to be considered, and they considered how this may enhance or detract from the conservation agenda of the zoo. The results revealed that although learning may occur at the zoo, it is not necessarily related to the educational material provided by the zoo. Learning tended to be indirect; for example, expressed curiosity about animals and the prevalence of descriptive statements about the animals indicated that zoos facilitate social interaction particularly between family and peer groups. Connections between humans and animals were also discovered, and the authors stated that visitors’ concern for animals increased after a zoo visit, which might lead to visitors’ support of conservation programmes. However, ultimately the authors concluded that even though visitors are open to learning at the zoo, education must fit into visitors’ leisure pursuits and it is the responsibility of the zoo to stimulate learning, possibly through social interaction (Clayton et al., 2009).

Wood (1998) analysed visitors’ conversation while viewing chimpanzees (*Pan troglodytes*), to investigate their response to varying enrichment conditions in the enclosure. Visitors made more positive comments, indicative of intellectual curiosity, when new enrichment was present and the chimpanzees were engaged in species typical behaviour (Wood, 1998). However, when ‘old’ (one-day old) enrichment was present and the animals were less active and more likely to engage in aberrant behaviour, visitors made more negative comments (Wood, 1998). One early study considered the difference in the type of comments adult visitors made at tamarins in cages versus a free-ranging environment (Price et al., 1994). The authors discovered that at the caged tamarin exhibit visitors mostly commented on the monkeys’ appearance and behaviour. The free-range exhibit lead to a greater variety and frequency of comments and more questions, indicative of interest and curiosity, but also more negative comments about the tamarins getting lost, biting people or complaints about difficulty in seeing them. Yet, the authors concluded that overall the visitors learned more from the free-ranging animals and that free-ranging animals instigated more insightful conversation (Price et al., 1994).

Conversation can indicate whether or not visitors are paying attention to an exhibit, which is a precursor for learning and the start of the cognitive process (Altman, 1998). Additionally, conversation reveals the visitors' immediate level of interest, curiosity and engagement at an exhibit, while taking into account personal, emotional and social experiences. The current research is perhaps the first study in Ireland to use conversation content analysis to reveal children's learning in the zoo setting.

The aims of this part of the research were to:

1) Reveal the types of comments made as children view animals at Fota Wildlife Park and Dingle Aquarium.
2) Consider which variables influence the diversity of positive and negative comments in the zoo setting.
3) Evaluate if overheard conversation reveals evidence of learning in the zoo setting.

8.2 Methodology

The study sites and animals viewed in this chapter are identical to those presented in Chapter 7 (see Table 7.1). For continuity, groups of children are nearly identical to those in Chapters 7; therefore, if a viewing session was discounted for analysis in the previous chapter it was not used in the current chapter (see Appendix 2). In total 49 groups of children were included in the study. The size of the groups varied between approximately 7 and 40 children, aged between 5 and 12 years (Table 8.1). At Fota Wildlife Park, some groups viewed both the lemurs and the Humboldt penguins, this was recorded as two separate conversations. Camp groups observed the animals twice, and their pre- and post-viewing conversations were recorded separately. This yielded 74 observed conversations between Fota Wildlife Park and Dingle Aquarium. Children's conversation was observed during two conditions: control (no educational intervention (EI), n=47) and treatment (with EI, n=27). The aim of the project was to achieve balance between treatment and control groups; however, due to schools' and institutions' scheduling this was not always possible. Furthermore, as described in Chapter 7, some unscheduled groups that arrived to view the Humboldt penguins were observed and their conversation recorded. These were always classified as control groups.

Procedure and data collection

Data collection in the current chapter followed the methodology described in Chapter 7. Data were collected from May, 2014 – August, 2016. Children's conversations were observed and recorded by the researcher at the same time as their behaviour (see Chapter 7). Most children stood in a group around the viewing area and the researcher stood amongst the children, moving with them if necessary (Tunnicliffe, 1998). It is possible that some conversations were missed, if children whispered or wandered from the main group, and at times acoustics and ambient noise made listening difficult (Allen, 2002). This was out of the control of the researcher.

Since this part of the research only comprised a small part of the overall project, digitally recording and transcribing the entire conversation was considered to be out of the scope of this study. Therefore, conversation data were collected using the Tunnicliffe Conversation Observation Record (TCOR) (Tunnicliffe, 2005). This is a checklist which

Table 8.1. Details of the groups that participated in the project at Fota and Dingle.

ID	Date	Tour or Camp	Gender	Age	No. of children in group	Condition	Species observed
FS141	June 2014	Tour	Mix	5 – 6	30	Treatment	P
FS142	June 2014	Tour	Mix	6 - 7	30	Control	P
FS145	June 2014	Tour	Girls	8 - 9	20	Treatment	P
FS146/7	June 2014	Tour	Girls	8 -9	40	Control	P
FS148	June 2014	Tour	Girls	9 – 10	18	Treatment	L
FS149	June 2014	Tour	Girls	9 - 10	19	Control	L
FS214*	June 2014	Tour	Mix	7 - 8	30	Control	P
FS414*	June 2014	Tour	Mix	6 - 7	25	Control	P
FS614*	June 2014	Tour	Mix	5 - 6	25	Control	P
FS151	June 2015	Tour	Mix	11 - 12	25	Treatment	P
FS153	June 2015	Tour	Mix	9 - 10	30	Treatment	P
FS154	June 2015	Tour	Mix	9 - 10	30	Treatment	P
FS155	June 2015	Tour	Mix	9 - 10	30	Control	P
FS156A	June 2015	Tour	Mix	10 - 12	15	Treatment	P
FS156B	June 2015	Tour	Mix	10 - 12	15	Treatment	P
FS157A	September 2015	Tour	Girls	11 - 12	17	Treatment	P
FS157B	September 2015	Tour	Girls	11 - 12	17	Treatment	P
FS158	September 2015	Tour	Girls	11 - 12	34	Control	P
FS115*	June 2015	Tour	Mix	9 – 10	26	Control	P
FS215*	June 2015	Tour	Mix	9 – 10	25	Control	P
FS515*	June 2015	Tour	Mix	9 – 10	25	Control	P
FS1015*	June 2015	Tour	Mix	9 – 10	30	Control	P
FS161	May 2016	Tour	Mix	10 - 12	36	Treatment	P
FS162	June 2016	Tour	Mix	10 -11	22	Treatment	P
FS163	June 2016	Tour	Mix	9-10	26	Control	P

Table 8.1 Continued. Details of the groups that participated in the project at Fota and Dingle.

ID	Date	Tour or Camp	Gender	Age	No. of children in group	Condition	Species observed
FC141	April 2014	Camp	Mix	7 – 12	19,10	Treatment	L/P
FC142	July 2014	Camp	Mix	7 – 12	25,24	Treatment	L/P
FC143	August 2014	Camp	Mix	7 – 12	17	Control	L/P
FC144	October 2014	Camp	Mix	7 – 12	8,7	Treatment	L
FC151	April 2015	Camp	Mix	7 – 12	32,10	Control	L/P
FC152	July 2015	Camp	Mix	9 - 12	14,11	Control	L/P
FC153	August 2015	Camp	Mix	9 - 12	16,15	Treatment	L/P
FC154	October 2015	Camp	Mix	7 - 12	24,5	Control	L
FC161	March 2016	Camp	Mix	7 - 12	17	Treatment	L
FC162	July 2016	Camp	Mix	7 - 12	18,19	Control	L/P
FC163	August 2016	Camp	Mix	7 - 12	18,16	Treatment	L/P
DS141	May 2014	Tour	Mix	11 - 12	19	Treatment	P
DS142	May 2014	Tour	Mix	11 - 12	30	Treatment	P
DS143	May 2014	Tour	Mix	11 -12	30	Control	P
DS144	May 2014	Tour	Mix	9 - 12	20	Control	P
DS145	May 2014	Tour	Mix	8 - 10	20	Control	P
DS151	May 2015	Tour	Mix	11-12	30	Control	P
DS152	May 2015	Tour	Mix	11-12	24	Treatment	P
DS153	May 2015	Tour	Mix	11-12	25	Control	P
DS154	May 2015	Tour	Mix	11-12	25	Control	P
DS155	May 2015	Tour	Mix	11-12	25	Treatment	P
DS156	May 2015	Tour	Mix	11-12	25	Treatment	P
DS161	May 2016	Tour	Mix	11-12	26	Control	P
DS162	May 2016	Tour	Mix	11-12	25	Treatment	P

* Denotes groups who were not scheduled participants of the study. Groups beginning with F=Fota Wildlife Park, D=Dingle Aquarium; number of children per camp group is approximate, two numbers denote pre, post groups. L=Lemurs only; P=Penguins only; L/P=Lemurs and Penguins.

was developed to determine if learning occurs during a zoo field trip (Patrick et al., 2013), and includes pre-designated categories of conversation, which is also similar to the methodology employed by Clayton et al. (2009). Using standard content analysis procedure (Cohen et al., 2007) both pre-existing categories of conversation based on the TCOR (Patrick and Tunnicliffe, 2012), and themes that emerged from preliminary research conducted at Dingle Aquarium and Fota Wildlife Park were used to generate a checklist of typical children's conversational comments while at the zoo.

During the preliminary research, children were overheard to make anthropocentric (humans as superior to animals) and anthropomorphic (attributing human characteristics to animals) comments. While it is common for children to take an anthropocentric attitude towards animals, education, especially when it includes viewing animals in nature, can shift anthropocentricism to a more biocentric attitude (Almeida et al., 2013). Therefore, anthropocentric remarks were classified here as negative because it was reasoned that they did not represent a pro-conservation attitude. However, anthropomorphic remarks, also common in children, were classified as positive because even though they can represent an unfair judgement of animals (Almeida et al., 2013) more often they are representative of an emotional connection (Clayton et al., 2009) or a general valuing of animals (Myers et al., 2003). This yielded 15 positive and 4 negative types of comments (Table 8.2).

For each group observation session, if a comment was made by any child in the research group, a tick was made next to the corresponding category on the checklist. Similar to Clayton et al. (2009) it was considered more important to know how many types of comments were made, than to record the frequency of each comment, therefore the occurrence, not the frequency of comments, is represented (Tunnicliffe et al., 1997). Each comment was counted in only one category, where overlap occurred between categories the most appropriate choice was made. It was not possible to determine which child made the comment so that the data represent the group rather than individual children. It is possible, though unlikely, that one child could have made all the comments that were recorded in one viewing session. At times when other visitors were present during observation sessions, their conversation was never purposefully recorded.

Table 8.2. Children's conversation comments recorded at exhibits at Fota Wildlife Park (lemurs and penguins) and Dingle Aquarium (penguins). Adapted from the TCOR (Tunnicliffe, 2005; Patrick and Tunnicliffe, 2012; p. 157).

Positive comments	**Definition**	**Example**
Non-zoo related	Social discourse not related to animals or the zoo	'I like your coat,' 'Do you want to come to my house?'
Management	Directional, management	'Look,' 'over there,' 'let's go'
Naming	Naming the animals on view, discussion of what to call them	'It's a penguin,' 'Is it a monkey?'
Descriptive	Describing the animal on view	'It's small,' 'They're fluffy'
Behaviour	Mention of the animals' behaviour	'They're swimming,' 'He's eating'
Location	Discussion of the animals' location	'It's over there,' 'Where are they?'
Exhibit	Discussion of the exhibit	'They're not in cages,' 'There's snow in there'
Information	Seeking or giving information	'They can't fly,' 'Where do they come from?'
Affective	An emotional comment, generally positive	'I love them!'
Enrichment	Reference to the enrichment provided	'He's looking at it,' 'Do they see it,' 'It's working'
Visitor effects	Discussion of visitor effects on animals, generally positive	'Don't frighten them,' 'I wonder if they notice us?'
Anthropomorphic	Reference to human characteristics of the animals	'He's waving,' 'They look like us'
Media	Reference or discussion of animals in the media	'I saw this on TV,' 'They're from that movie'
Science	Reference to science	'The hypothesis was right!' 'This is our experiment'
Conservation/zoo-related	Anything having to do with conservation, or zoo-related discussion	'Tigers are going extinct,' 'Deforestation is bad'
Negative comments	**Definition**	**Example**
Feed/touch/Bang	Discussion of feeding or touching with a negative reference or banging the glass at Dingle Aquarium	'Give them this,' 'Let's touch one'

Table 8.2 Continued. Children's conversation comments recorded at exhibits at Fota Wildlife Park (lemurs and penguins) and Dingle Aquarium (penguins). Adapted from the TCOR (Tunnicliffe, 2005; Patrick and Tunnicliffe, 2012; p. 157).

Negative comments	Definition	Example
Negative comments	Generally negative comments	'This is boring,' 'I hate them'
Misinformation	Giving incorrect information	'There should be ice in there' 'He'll fly out'
Anthropocentric	Reference to people controlling animals or being 'in charge' of them.	'They can't live without us,' 'I'll make them run'

Data analysis

Although only the primary researcher recorded conversation data, for the purposes of reliability and quality assurance a research assistant simultaneously recorded children's conversation during two sessions and inter-observer reliability testing was carried out between the primary researcher and the research assistant using Cohen's kappa (Jensen, 2014). A mean of 0.745 (a positive association on a scale from -1 to +1) was achieved for inter-observer reliability testing during this part of the study (Appendix, Table A1 of this chapter).

First, using descriptive statistics, data collected at each exhibit are presented in bar charts and table format, where the proportion of control or treatment groups to make each type of comment is shown (Figures 8.1 - 8.2 and Tables 8.3 - 8.5). Since categories of conversation are not mutually exclusive, the total of the categories is over 1.00 (Tunnicliffe et al., 1997). For subsequent analysis, comments were categorised as either positive or negative. In this case, the dependent variables were the proportion of positive and negative comments made per viewing session and are referred to as the 'diversity' of positive or negative comments. Data were tested for normality using the Kolmogorov-Smirnov test, and visually inspected with histograms and quantile-quantile plots. Then data were examined with general linear models or the Mann-Whitney U test. Preliminary research indicated that no differences occurred between the conversations of pre- and post-camp control groups (See Appendix, Table A2 of this chapter). As in Chapter 7, for the purpose of the analysis, camp treatment groups that had not yet received the educational intervention (pre-groups) were included with the control group. Independent variables were tested for multicollinearity and were found to be below the variance inflation factor (VIF) tolerance level of 2.5 in all cases, indicating that the independent variables are not too closely related. Here, a discussion is incorporated into the descriptive statistics section for each species, and a general discussion follows.

8.3 Results and discussion

8.3.1 Descriptive statistics – results and discussion

Diverse positive conversations took place as both control (Figure 8.1) and treatment groups (Figure 8.2) viewed the species included in the study at each exhibit, however more types of positive comments occurred in treatment groups. For both control and treatment groups, location and visitor effects were generally mentioned more by groups viewing lemurs than the groups viewing penguins (Figure 8.1 and 8.2), presumably because the lemurs could move location and the free-ranging animals made children more aware of their potential to affect them through unrestricted interaction. This increase in conversation supports the findings of Price et al. (1994), who concluded that visitors prefer to see and learn more from animals that can roam freely. Equally, both groups mentioned the Humboldt penguins' location more than the Gentoo's location, again presumably because the penguins at Fota were more difficult to find in their naturalistic enclosure (Figure 8.1 and 8.2). However, children at Dingle made more or equal comments about the exhibit than at the other locations, possibly because the penguins were visible underwater (Figure 8.1 and 8.2). This is supported by the fact that every group to visit Dingle Aquarium commented on the penguins' behaviour (Table 8.5), which offers further evidence that animal activity affects children's engagement (Altman, 1998).

More diversity in negative conversation occurred while control groups viewed animals than treatment groups (Figure 8.3). Similar to Price et al. (1994), groups made the most comments about touching/feeding/banging at the free-range exhibit, but the fewest generally negative comments at the lemur exhibit (Figure 8.3). This difference could also be due to the different species in the current study rather than the enclosure type.

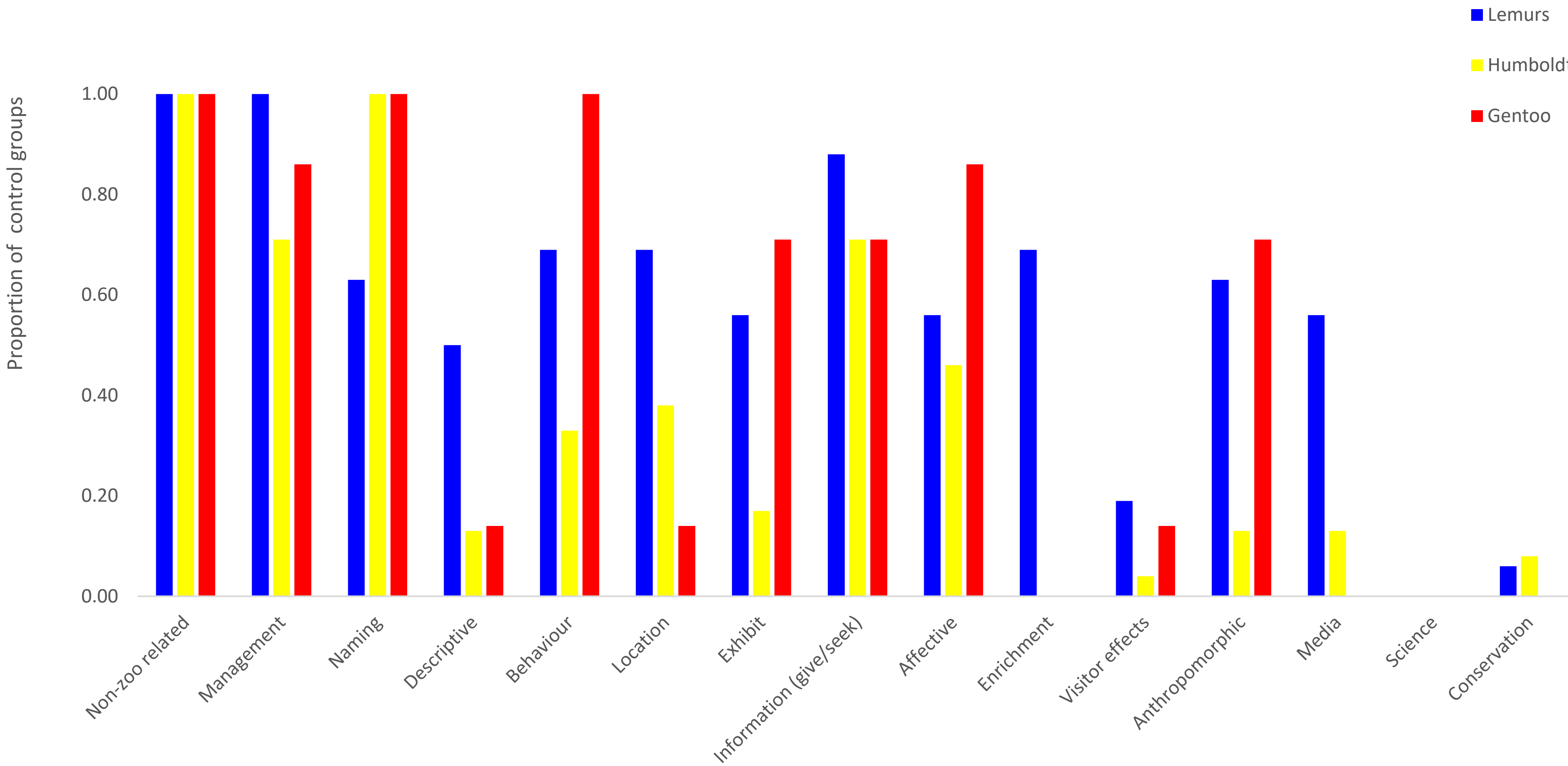


Figure 8.1. Proportion of control groups to make positive comments at the ring-tailed lemur and Humboldt penguin exhibits (Fota Wildlife Park) and the Gentoo penguin exhibit (Dingle Aquarium).

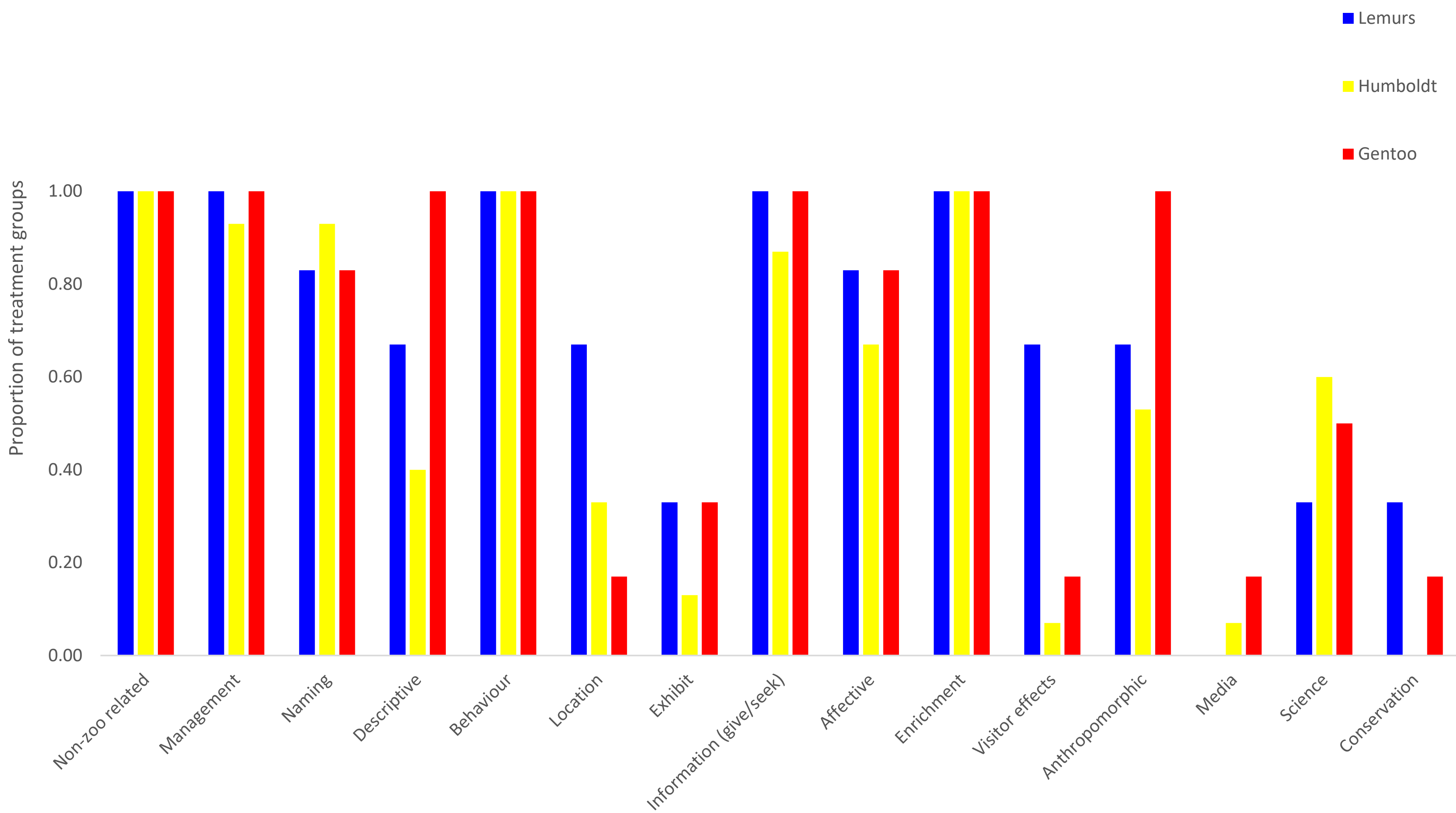
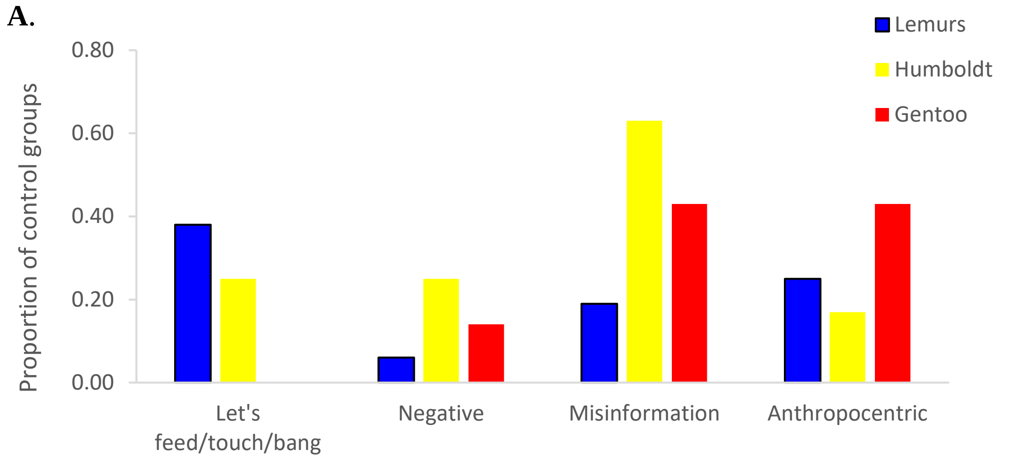


Figure 8.2. Proportion of treatment groups to make positive comments at the ring-tailed lemur and Humboldt penguin exhibits (Fota Wildlife Park) and the Gentoo penguin exhibit (Dingle Aquarium).



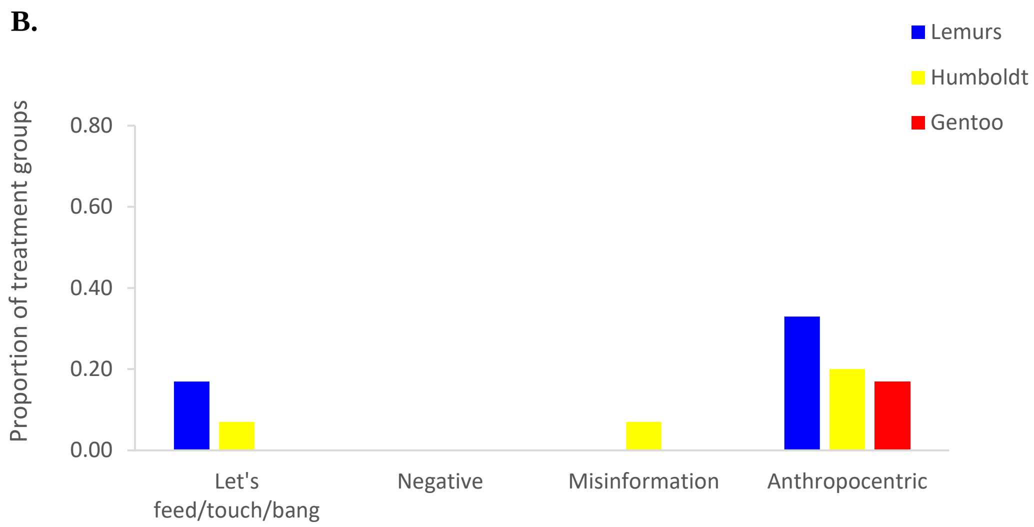


Figure 8.3. Proportion of A) control groups and B) treatment groups to make negative comments at the ring-tailed lemur and Humboldt penguin exhibits (Fota Wildlife Park) and Gentoo penguin exhibit (Dingle Aquarium).

Table 8.3. Results of children's conversation at Fota Wildlife Park's lemur exhibit presented as control and treatment groups.

Ring-tailed lemurs - Fota Wildlife Park	**Control group** n=16	**Treatment group** n=6
Positive Comments:		
Non-zoo related	1.00	1.00
Management	1.00	1.00
Naming	0.63	0.83
Descriptive	0.50	0.67
Behaviour	0.69	1.00
Location	0.69	0.67
Exhibit	0.56	0.33
Information (give/seek)	0.88	1.00
Affective	0.56	0.83
Enrichment	0.69	1.00
Visitor effects	0.19	0.67
Anthropomorphic	0.63	0.67
Media	0.56	0.00
Science	0.00	0.33
Conservation	0.06	0.33
Negative Comments:		
Let's feed/touch	0.38	0.17
Negative	0.06	0.00
Misinformation	0.19	0.00
Anthropocentric	0.25	0.33

Fota Wildlife Park – Ring-tailed lemurs

Table 8.3 shows that at the ring-tailed lemur exhibit, for almost every category of positive conversation, treatment groups were equally or more likely than control to make comments, including naming (83% vs 63%), describing (67% vs 50%), mentioning behaviour (100% vs 69%) giving or seeking information (100% vs 88%) visitor effects (67% vs 19%) and affective comments (83% vs 56%). At the lemur exhibit, enrichment was present for both control and treatment groups and 69% of control groups and 100% of treatment groups mentioned it. Both control (69%) and treatment (67%) groups discussed the animals' location approximately equally, presumably locating and seeing the animals was a priority for both groups (Table 8.3). However, more control groups (56%) than treatment groups (33%) talked about the actual exhibit (Table 8.3). This may be because the treatment groups were told about the free-range exhibit during the EI and were not surprised by it. At the lemur exhibit, 56% of control groups compared to 0% treatment groups discussed media; reasons for this are uncertain. Control groups visiting the lemurs were more likely than treatment groups to make negative comments in every category except anthropocentric (Table 8.3).

Fota Wildlife Park – Humboldt penguins

Although the penguins represent a different taxonomic group than the lemurs, the children's conversation followed a similar pattern as they viewed them, with treatment groups at the Humboldt penguin exhibit making a more diverse range of positive comments and fewer types of negative comments than control groups (Table 8.4). Treatment groups were more likely than control groups to describe the animals (40% vs 13%), discuss enrichment (100% vs 0%), science (60% vs 0%) the animals' behaviour (100% vs 30%) and make anthropomorphic (53% vs 13%) and affective (67% vs 46%) comments (Table 8.4). This suggests that children in the treatment group had a more insightful and emotionally rich experience, indicative of more profound learning (Tunnicliffe et al., 1997; Clayton et al., 2009; Bexell et al., 2013). Interestingly, more control groups (8%) than treatment groups (0%) discussed conservation, the reason for this is uncertain, but since it is a low percentage it is probably not reflective of control groups in general (Table 8.4). The control groups

Table 8.4. Results of children's conversation at Fota Wildlife Park's Humboldt penguin exhibit presented as control and treatment groups.

Humboldt penguins - Fota Wildlife Park	**Control group** n=24	**Treatment group** n=15
Positive Comments:		
Non-zoo related	1.00	1.00
Management	0.71	0.93
Naming	1.00	0.93
Descriptive	0.13	0.40
Behaviour	0.33	1.00
Location	0.38	0.33
Exhibit	0.17	0.13
Information (give/seek)	0.71	0.87
Affective	0.46	0.67
Enrichment	0.00	1.00
Visitor effects	0.04	0.07
Anthropomorphic	0.13	0.53
Media	0.13	0.07
Science	0.00	0.60
Conservation	0.08	0.00
Negative Comments:		
Let's feed/touch	0.25	0.07
Negative	0.25	0.00
Misinformation	0.63	0.07
Anthropocentric	0.17	0.20

made more negative comments than treatment groups, particularly giving misinformation (63% vs 7%), followed by discussion of feeding or touching (25% vs 7%) and generally negative remarks (25% vs 0%) (Table 8.4). Approximately equal percentages of groups (17% of control, 20% of treatment) made anthropocentric comments (Table 8.4).

Dingle Aquarium – Gentoo penguins

Results from the Gentoo penguin exhibit at Dingle Aquarium are broadly similar to the Humboldt penguins at Fota Wildlife Park. Table 8.5 indicates that at the Gentoo penguin exhibit at Dingle Aquarium, treatment groups were more likely than control groups to describe the animals (100% vs 14%), discuss enrichment (100% vs 14%) and science (50% vs 0%), mention conservation (17% vs 0%) and the media (17% vs 0%) or make anthropomorphic remarks (100% vs 71%). Treatment groups were also more likely than control groups to give and seek information (100% vs 71%), which suggests students are explaining their observations based on previous experience (Patrick and Tunnicliffe, 2012), a precursor for learning (Tunnicliffe et al., 1997). However, more control group than treatment groups named the animals (100% vs 83%) and made comments about the exhibit (71% vs 33%) (Table 8.5). Surprisingly, approximately equal numbers of control (14%) and treatment groups (17%) mentioned visitor effects. Many of the comments had to do with photography (e.g. 'the flash will scare them'), which was reflective of the signs present in the penguin exhibit and could indicate that children read the signs. This is in contrast to the findings of Clayton et al. (2009), who reported that visitors did not read signage. Additionally, Clayton et al. (2009) reported that in their study 88% of visitors described the penguins, which the authors' attributed to social interaction. However, in the current study 100% of treatment groups, but only 14% of control groups described the penguins. This suggests that descriptive comments are more indicative of learning than social interaction since the only difference between the groups was the educational intervention that they had received. Patrick and Tunnicliffe (2012) also stated that naming and describing animals is an essential early step in the learning process. Again, control groups viewing penguins at Dingle Aquarium were more likely to engage in negative conversations than treatment groups (Table 8.5). This mostly involved giving misinformation or making anthropocentric comments. None of the treatment groups, compared to 14% of control groups, made negative comments such as ‘this is stupid’ or ‘I don’t like them’ as they viewed the birds (Table 8.5).

Table 8.5. Results of children’s conversation at Dingle Aquarium’s penguin exhibit presented as control and treatment groups.

Gentoo penguins - Dingle Aquarium	**Control group** n=7	**Treatment group** n=6
Positive Comments:		
Non-zoo related	1.00	1.00
Management	0.86	1.00
Naming	1.00	0.83
Descriptive	0.14	1.00
Behaviour	1.00	1.00
Location	0.14	0.17
Exhibit	0.71	0.33
Information (give/seek)	0.71	1.00
Affective	0.86	0.83
Enrichment	0.00	1.00
Visitor effects	0.14	0.17
Anthropomorphic	0.71	1.00
Media	0.00	0.17
Science	0.00	0.50
Conservation	0.00	0.17
Negative Comments:		
Let’s bang the glass	0.00	0.00
Negative	0.14	0.00
Misinformation	0.43	0.00
Anthropocentric	0.43	0.17

8.3.2 Inferential statistics - results

Plotted histograms and the Kolmogorov-Smirnov test revealed that comments observed during children's conversation were non-normally distributed (positive comments $p=0.038$; negative comments $p<0.001$; p-values are significantly different from normal). However, positive comments were approaching normal and a visual inspection of the histogram revealed a nearly normal curve. Therefore, a GLM was used to model the diversity of positive comments against the independent variables described (Table 8.6). Graphs of standardised residuals were inspected throughout the analysis to ensure that the assumptions of normality were maintained. The diversity of negative comments was not normally distributed and therefore, the Mann-Whitney U test was used to test for differences in negative comments between treatment and control groups, which was the primary focus of the study.

Table 8.6. Details of the dependent and independent variables investigated.

Dependent variables	Independent variables	Response options
1) Positive comments	1) Condition	Control or Treatment
2) Negative comments*	2) Species	Gentoo penguins; Humboldt penguins; Ring-tailed lemurs
	3) Educational experience	1-day school tour or 5-day camp
	4) Age	$0=\leq 8$; 1=9-13; 2=9-10; 3=11-13
	5) Length of session	Time in minutes
	6) No. of children	No. of children counted in the group

*Condition only

Positive comments

The general linear model indicated that condition ($p<0.001$) and species ($p<0.001$) affected the proportion of positive comments (see Appendix, Table A3 of this chapter for complete model). Children in the treatment group expressed a more diverse range of positive comments than those in the control group (Figure 8.4). Additionally, conversations that took place at the Gentoo penguins and ring-tailed lemurs were more diverse than those that occurred at the Humboldt penguins (Figure 8.5). No significant interactions occurred between any of the independent variables tested. Additionally, participation in a tour or camp, the age and number of the children observing the animals, and the length of the viewing session did not affect the diversity of positive comments.

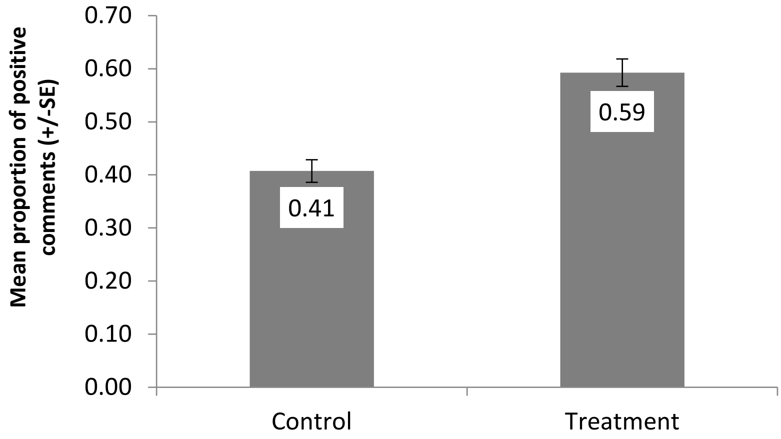


Figure 8.4. The mean proportion of positive comments made per viewing session by control and treatment groups at all animal exhibits.

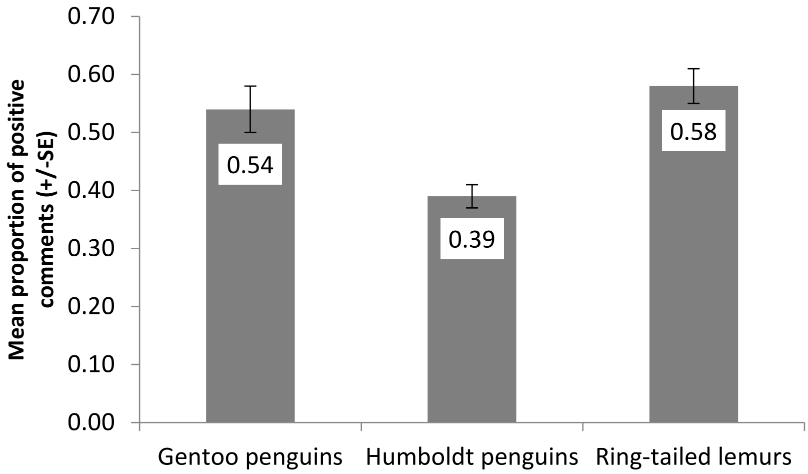


Figure 8.5. The mean proportion of positive comments made by all groups of children at Gentoo penguin, Humboldt penguin and ring-tailed lemur exhibits.

Negative comments

The Mann-Whitney U test revealed a statistically significant difference for the diversity of negative conversation between treatment and control groups (U=292.00, p<0.001). Children in the control group made more types of negative comments while viewing animals than those in the treatment groups (Figure 8.6).

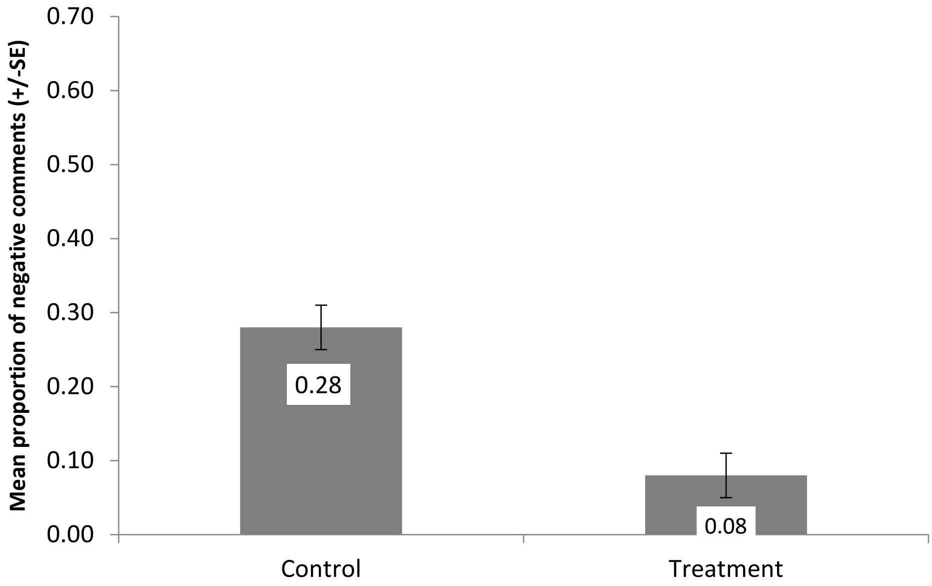


Figure 8.6. The mean proportion of negative comments made per viewing session by control and treatment groups at all animal exhibits.

8.4 General discussion

The results found here support the findings of other studies that report that visitors make comments that are indicative of curiosity, cognitive engagement and emotional connections as they view animals (Price et al., 1994; Clayton et al., 2009). Although the current study did not analyse the order of the comments, the same type of comments reported by Tunnicliffe et al. (1997) (e.g. location, naming, describing, discussion of behaviour and interpretation based on previous knowledge) were observed.

A pattern emerged which showed that irrespective of the location or species, treatment groups made more types of positive comments, and control groups made more types of negative comments. A closer inspection of the comments revealed that in general the treatment groups made more comments indicative of learning (naming, describing and commenting on behaviour), curiosity about the animals on display (giving and seeking information) and emotional connection to the animals (affective and anthropomorphic) than control groups. Furthermore, the treatment groups commented on topics (enrichment, science and visitor effects) that they had learned about during the EI. In contrast, control groups were more likely than treatment groups to make comments giving misinformation, about touching or feeding the animals, or generally negative comments. In fact, participation in the control or treatment groups was one of only two variables found to significantly influence the proportion of positive comments that groups made.

Indeed, in the current study many of the independent variables tested did not affect diversity of positive comments, including children's age. This concurs with previous studies that reported little difference in the content of conversation between children of different ages (Tunnicliffe, 1996b) or genders (Tunnicliffe, 1998). Gender was not evaluated in the current study because most groups were of mixed gender and it was difficult to determine if a boy or girl made the comment. However, despite the earlier findings of Tunnicliffe (1998), gender should be included in future research since previous research from this thesis (Chapters 5 and 6) revealed differences in learning at zoos and aquariums between boys and girls.

Neither was diversity of positive comments affected by participation in a camp or a tour, the number of children present in the group or the length of their stay at the exhibit. Since it was difficult to control group numbers or how long visitors stayed at the exhibit, this is a useful finding for future researchers. Previous research has equated longer visitor stay time at exhibits with visitor interest and perhaps enhanced learning (Clayton et al., 2009; Moss and Esson, 2010). Interestingly, in the current study longer stay time was not associated with more types of positive comments; however, the length of the viewing session was generally controlled by the zoo staff and school teacher's schedule and did not necessarily reflect the students' level of interest. It was not possible during the current research to record the frequency of the comments, which child made the comment or the verbatim conversation, which may have minimised the effect of certain variables.

Children generally made fewer negative remarks than positive remarks (Clayton et al., 2009); however, negative remarks were more common in control groups. Many of the negative comments centred around misinformation. For example, at the Fota Wildlife Park penguin exhibit, a child exclaimed 'they're too hot'. The child is basing this misinformation on previous experience and understanding (Tunnicliffe et al., 1997) perhaps influenced by the media (Wagoner and Jensen, 2010). However, the child did not then encounter anything during the visit to adjust their prior understanding (Patrick and Tunnicliffe, 2012). Ideally, a teacher or parent should correct this misinformation. However, recording adult remarks was out of the scope of this study, and Patrick and Tunnicliffe (2012) report that many teachers or parents are not able to give the correct information. The EI specifically addressed the importance of not attempting to feed or touch zoo animals, so it is encouraging that treatment groups engaged in fewer conversations about this type of behaviour.

The motivation for anthropocentric comments is less clear, and the results found here do not support what previous studies have discovered. Almeida et al. (2013) and Borchers et al. (2014) reported that environmental education may reduce anthropocentrism in children, but at Fota Wildlife Park the treatment group made more anthropocentric comments than the control group. Many of the anthropocentric comments heard in the present study involved children commenting that they could or would make the animals do something ('I can make them run!' 'See if you can make him jump'), suggesting that there is a link between anthropocentric comments and frustration that the animals are not active. The enrichment (present with the treatment groups) was intended to promote animal activity; however, it was not especially effective and the animals were not necessarily more active when the treatment groups were present (see Chapter 7). A more effective type of enrichment which encourages animal activity (Altman, 1998) may reduce anthropocentric comments. Also, at Fota, the treatment groups gave the enrichment to the penguins, which may cause children to feel 'in control' of the animals. Whereas at Dingle, where treatment groups made fewer anthropocentric comments, children in the treatment group did not directly distribute the enrichment. While it is positive for children to develop a sense of empowerment to help the environment (Hungerford and Volk, 1990), future research should ensure this does not include a sense of authority over the animals.

Display species also affected the diversity of positive comments, which could be due environmental factors such as enclosure design and animal activity (Clayton et al., 2009). For example, in a previous study, primates received the highest proportion of comments and Clayton et al. (2009) related this to their human-like appearance, and free-ranging species are reported to receive more comments than traditionally caged ones (Price et al., 1994; Clayton et al., 2009). Indeed, in the current study the free-ranging ring-tailed lemurs received the most diverse range of positive comments and a high number of anthropomorphic comments from both control and treatment groups, offering further evidence that visitors are more engaged with and potentially learn more from a free-ranging species. The Gentoo penguins received more positive comments than the Humboldt penguins, possibly because of the Gentoo penguins' larger stature, distinctive pattern, easy visibility and the ability of visitors to observe them swimming underwater. Also, at Fota, penguins received negative remarks about their 'bad smell,' however, at Dingle, the penguins were behind a glass wall so no smell was apparent, though Jensen (2011) states that 'smell' can be a prominent and memorable feature of a zoo visit for children.

Animal activity level influences visitor conversation (Altman, 1998; Wood, 1998; Clayton et al., 2009). For example, a group that saw a snake being fed made a greater variety of comments than a similar one that was not fed during the observation period (Clayton et al., 2009), and visitors made more animal behaviour related comments and fewer human-directed comments when polar bears were active (Altman, 1998). Wood (1998) also found that visitors made more positive comments when enrichment was present in a chimpanzee enclosure. These results reflect those of the current study, which found that, when enrichment was present, a greater diversity of positive comments and a lower diversity of negative comments occurred. Of course, it may be that in the present study the treatment group was more engaged with the animals because of the knowledge they gained during the EI and not because of the presence of the enrichment, which did not always result in increased animal activity. Separating the influence of the EI and the presence of enrichment was not possible but could be an area for further research.

The research project employed a mixed-method approach to data collection and results from this section of the project support results discovered in other chapters. For example, here it was discovered that treatment groups engaged in more diverse positive conversation as they viewed animals. When this is considered together with the results of Chapter 5, which showed that the treatment groups were more likely to have increases in knowledge and behavior on the survey than control groups, this reinforces the evidence that the educational intervention enhanced learning in the zoo. Also, in the present chapter treatment groups made fewer negative comments about touching or feeding the animals at Fota, which supports the findings of Chapter 7 that treatment groups are less likely to exhibit negative behavior while viewing animals. Not only does the conversation data strengthen the findings of the other chapters, but it shows that conversational content analysis provides a unique insight into learning at the zoo (Tunnicliffe, 1996a), and is useful to uncover indirect learning. For example, the present study previously found that children were disinclined to answer open-ended questions on the survey (see Chapter 5) and interviewing children can be logistically difficult. However, listening to what children say as they view animals is easy to implement and may reveal learning that would not be discovered with survey questions alone, such as emotional engagement with animals.

8.5 Conclusions

1. Both control and treatment groups engaged in a diverse range of positive conversation at each exhibit they viewed.
2. The diversity of positive conversation was affected by condition (control or treatment). Treatment groups engaged in more types of positive comments than control groups, indicative of more in-depth learning.
3. The diversity of positive conversation was also affected by species. More types of positive comments were made at ring-tailed lemur exhibit than the penguin enclosures, which may suggest that visitors prefer to see and learn more from the free-ranging species.
4. Control groups made more types of negative comments than treatment groups.

8.6 References

Allen, S. (2002). Looking for learning in visitor talk: A methodological exploration. In *Learning Conversations in Museums*. (Eds.) G. Leinhardt, K. Crowley & K. Knutson. Mahwah, Lawrence Erlbaum Associates: 259-303.

Almeida, A., Vasconcelos, C. M., Strecht-Ribeiro, O. & Torres, J. (2013). Non-anthropocentric reasoning in children: Its incidence when they are confronted with ecological dilemmas. *International Journal of Science Education*, 35(2), 312-334.

Altman, J. D. (1998). Animal activity and visitor learning at the zoo. *Anthrozoös,* 11(1), 12-21.

Bexell, S. M., Jarrett, O. S. & Ping, X. (2013). The effects of a summer camp program in China on children's knowledge, attitudes, and behaviors toward animals: A model for conservation education. *Visitor Studies*, 16(1), 59-81.

Borchers, C., Boesch, C., Riedel, J., Guilahoux, H., Ouattara, D. & Randler, C. (2014). Environmental education in Côte d'Ivoire/West Africa: Extra-curricular primary school teaching shows positive impact on environmental knowledge and attitudes. *International Journal of Science Education, Part B*, 4(3), 240-259.

Clayton, S., Fraser, J. & Saunders, C. D. (2009). Zoo experiences: Conversations, connections, and concern for animals. *Zoo Biology*, 28(5), 377-397.

Cohen, L. M., Manion, L. l. & Morrison, K. (2007). *Research methods in education, 6*. Routledge: London and New York.

Falk, J. H. & Dierking, L. D. (2000). *Learning from Museums: visitor experiences and the making of meaning*. Walnut Creek, CA. Alta Mira Press.

Hungerford, H. R. & Volk, T. L. (1990). Changing learner behavior through environmental education. *The Journal of Environmental Education*, 21(3), 8-22.

Jensen, E. (2011). *Learning about Animals, Science and Conservation at the Zoo: Large-scale survey-based evaluation of the educational impact of the ZSL London Zoo Formal Learning programme.* A report to The Zoological Society of London.

Jensen, E. (2014). Evaluating children's conservation biology learning at the zoo. *Conservation Biology*, 28(4), 1004-1011.

Moss, A. & Esson, M. (2010). Visitor interest in zoo animals and the implications for collection planning and zoo education programmes. *Zoo Biology*, 29(6), 715-731.

Myers Jr, O. E., Saunders, C. D. & Garrett, E. (2003). What do children think animals need? Aesthetic and psycho-social conceptions. *Environmental Education Research*, 9(3), 305-325.

Patrick, P. G., Matthews, C. E., Ayers, D. F. & Tunnicliffe, S. D. (2007). Conservation and education: prominent themes in zoo mission statements. *The Journal of Environmental Education*, 38(3), 53-60.

Patrick, P. G. & Tunnicliffe, S. D. (2012). *Zoo Talk*. Springer Science & Business Media.

Patrick, P., Mathews, C. & Tunnicliffe, S. D. (2013). Using a field trip inventory to determine if listening to elementary school students' conversations, while on a zoo field trip, enhances preservice teachers' abilities to plan zoo field trips. *International Journal of Science Education*, 35(15), 2645-2669.

Price, E. C., Ashmore, L. A. & McGivern, A. M. (1994). Reactions of zoo visitors to free-ranging monkeys. *Zoo Biology*, 13(4), 355-373.

Tunnicliffe, S. D. (1996a). Conversations within primary school parties visiting animal specimens in a museum and zoo. *Journal of Biological Education*, 30(2), 130-141.

Tunnicliffe, S. D. (1996b). The relationship between pupils' age and the content of conversations generated at three types of animal exhibits. *Research in Science Education, 26*(4), 461-480.

Tunnicliffe, S. D. (1998). Boy talk/girl talk: is it the same at animal exhibits? *International Journal of Science Education*, 20(7), 795-811.

Tunnicliffe, S. D. (2005, January). Do your visitors talk about your exhibits? What do they say? Presentation given at Visitor Studies Day: Victoria and Albert Museum, London, UK. http://www.leeds.ac.uk/educol/documents/168630.htm Date last accessed April 4, 2018.

Tunnicliffe, S. D., Lucas, A. M. & Osborne, J. (1997). School visits to zoos and museums: a missed educational opportunity? *International Journal of Science Education*, 19(9), 1039–1056.

Wagoner, B. & Jensen, E. (2010). Science learning at the zoo: Evaluating children's developing understanding of animals and their habitats. *Psychology & Society*, 3(1), 65-76.

Wood, W. (1998) Interactions among environmental enrichment, viewing crowds, and zoo chimpanzees (*Pan troglodytes*). *Zoo Biology*, 17, 211-230.

Chapter 8: Appendix

Table A1. Results of the Cohen's kappa test between the primary researcher and a research assistant at Fota Wildlife Park for children's conversation at two exhibits. N = the number of conversation categories.

Site	N	r_s	*p*
Fota - Lemurs	18	0.667	0.003
Fota - Penguins	18	0.824	$p < 0.001$

Table A2. Results of the Wilcoxon signed ranks test for pre and post control group camps.

	Positive comments lemurs	Negative comments lemurs	Positive comments penguins	Negative comments penguins
Z	-0.813	-0.447	-0.184	-0.577
P – value	0.416	0.655	0.854	0.564

Table A3. Models applied for diversity of positive conversation using GLMs.

Model	Independent variables	Description	Variables removed from the model, p-value
M1	Condition + Species+ Educational experience+ Age + Length of session + No of children in group	All variables	Length of session, p=0.878
M2	Condition + Species+ Educational experience+ Age + No of children in group		Educational experience, p=0.677
M3	Condition + Species+ Age + No of children in group		No. of children in group, p=0.639
M4	Condition + Species+ Age		Age, p=0.344
	Variable remaining in the model	**Description**	**p-value**
M3	Condition + Species	Final Model	$p < 0.001$ (both variables)

All possible interactions were also included in the model, however none of them were close to statistical significance.

Chapter 9

Is knowledge related to behaviour?

Abstract

The ultimate goal of environmental education, including zoo-based education, should be pro-conservation behaviour change. Yet, this is something that has proven difficult to reliably measure, especially with children. Since knowledge gain as a result of a zoo visit is often a more achievable measure of learning, it may be possible for zoos to demonstrate pro-conservation behaviour change if a relationship exists between knowledge and behaviour. However, previous research in this area is inconclusive, particularly regarding children. The current study builds on data previously collected to investigate if a relationship exists between knowledge and behaviour in the zoo setting. The results showed that increased knowledge, demonstrated in the survey, was associated with a reduction in negative behaviour as children viewed penguins, indicative of pro-conservation behaviour. More research is required, but these data suggest that knowledge gained during the educational experience is related to positive behaviour, which could facilitate the ambitions of zoos to show themselves to be effective at influencing behaviour change.

9.1 Introduction

Despite criticisms that zoos have not substantiated claims to be environmental educators with empirical evidence (Jensen, 2011; Moss and Esson, 2013), recent research has found that zoos and aquariums are effective educators (Moss et al., 2015; Chapter 5 of this thesis) and that learning lasts beyond the immediate experience (Jensen et al., 2017; Chapter 6 of this thesis). Yet, evidence of knowledge gain no longer signifies successful conservation education (Bexell et al., 2013); pro-environmental behaviour change and the development of new patterns of positive behaviour are the more desirable goals (UNESCO, 1978; Hungerford and Volk, 1990; Ogden and Heimlich, 2009). Limited previous research has discovered pro-conservation behaviour change after participation in an environmental education (EE) programme (Ballantyne and Packer, 2002; Bexell et al., 2013; Chapter 7 of this thesis), but generally it has proven difficult for zoos and EE programmes to demonstrate actual behaviour change associated with their education programmes (Smith et al., 2008).

Behaviour change is a complex area, which can be difficult to define and measure (Dierking et al., 2004; Smith et al., 2008), and there is no standard protocol for EE programmes to achieve positive environmental actions (Borchers et al., 2014). Perhaps it is because of the complexity and difficulty in assessing behaviour change that most educational research in the zoo has focused on achieving knowledge gain (Dierking et al., 2004; Visscher et al., 2009; Jensen, 2011). This leads to the following question: Is knowledge acquired during an educational experience associated with subsequent behaviour change? Intuitively, it seems that a link between knowledge and behaviour exists, which is reinforced with well-known expressions like the phrase said by a park ranger and quoted by Freeman Tilden ‘Through interpretation, understanding; through understanding, appreciation; through appreciation, protection’ (Ham, 2009, p. 50). Yet, previous research in this area is inconclusive.

Some research suggests that knowledge does not necessarily lead directly to attitude or behaviour change (Bogner, 1998; Ham 2007). If learning is indeed constructivist in nature (Hein, 1998), with visitors making their own meaning from an experience (Falk and Dierking, 2000) than it follows that behaviour change will vary with visitors’ different experiences and this will affect outcomes (Dierking et al., 2004). Ham

(2007) draws on the theories of planned behaviour (Ajzen, 1985; 1991), which state that attitude and behaviour are based on a small set of significant beliefs. To effectively change behaviour, an educator must impact those exact beliefs, which is difficult to achieve with a diverse audience during a brief encounter. The author concludes that 'learning does not necessarily lead to liking or caring,' but if educators present strongly relevant themes, which provoke an audience to think deeply, then behaviour change is possible (Ham, 2007, p. 42). However, if conservation education starts in childhood, when children have a natural concern for animals' wellbeing, and they have not yet formed established belief systems, they may be more open to environmental messages (Myers, 2007; Bexell et al., 2013).

Despite the many variables involved and the different aspects of psychology which influence conservation behaviour, a large meta-analysis of environmental education data discovered weak to moderate correlations between pro-environmental knowledge, attitude, intention to act and behaviour (Hines et al., 1987), and a follow-on study 20 years later found similar results (Bamberg and Möser, 2007). However, Bamberg and Möser (2007) explain further that knowledge, awareness and intention, interact with internal emotions such as, guilt, moral and social norms to affect behaviour change. While knowledge gain may not lead directly to behaviour change, it is likely to facilitate pro-environmental actions or behaviours (Borchers et al., 2014). Bexell et al. (2013) reported that the child campers in their study said that the new knowledge gained during the environmental education experience made them change their behaviour towards animals. Thus, a lack of knowledge could impede behaviour change (Kuhar et al., 2010; Boeve-de-Pauw and Van Petegem, 2011), but knowledge alone is not sufficient to change behaviour (Borchers et al., 2014).

Higher post-survey scores than pre-survey scores indicate overall knowledge gain after a zoo visit (Jensen 2011; Moss et al. 2015; Chapter 5 of this thesis). Additionally, on-site behaviour has been observed to improve after an environmental educational intervention (Bexell et al., 2013; Chapter 7 of this thesis). However, rarely has empirical evidence shown an association between knowledge and positive behaviour change in children during the zoo experience. This part of the thesis builds on results discovered during the research and investigates associations between knowledge and behaviour to determine if zoos are in fact meeting the goal of pro-environmental behaviour change.

The aim of this part of the research was to:

1) Determine if an association exists between knowledge and observed behaviour.

9.2 Methodology

Procedure

The children participating in the research, the institutions involved, the animals observed, the surveys administered and the procedures followed are the same as those previously described in this thesis. The rate of negative children's behaviour analysed in the current chapter uses the same data that were described in Chapter 7. The surveys are the same as those described in Chapters 5. However, because the rate of negative behaviour observed was for the group of children, the mean survey score was calculated for each group and used in the current analysis. Only groups that both observed the animals and completed the survey were included in the current chapter, so that for each group that observed the animals there is a corresponding survey score (Table 9.1). According to Wellington and Szczerbinski (2007) this mixed-method approach to data collection and analysis allows for results to be understood more fully. However, the children in the observation group were not always exactly the same children who completed the survey, due to situations beyond the control of the researcher, such as absences and younger siblings attending the observation sessions. Only data collected from the post-survey (directly after the educational experience) were used in this section of the research, because this allowed for learning outcomes attributable to the educational experiences to be evaluated. Additionally, data from the lemur observation sessions were excluded from the study because there were too few observations. This yielded a total sample size of 34.

Data analysis

A GLM was considered for analysing the data. However, since previous sections of the thesis already discovered that a number of the independent variables tested (condition, site and educational experience) impact the results of the survey score and observed negative behaviour it was decided that it was not necessary to include these variables again. Therefore, to simplify the analysis, a Spearman's rank-order correlation test was used to test for a correlation between knowledge and observed behaviour. Data from school tours and camps, Dingle Aquarium and Fota Wildlife Park and control and treatment groups are included together in one analysis with the objective of discovering if an association between knowledge and observed behaviour exists regardless of the other variables involved. Plotted histograms, quantile-quantile plots and the Kolmogorov-Smirnov test (p=0.077 negative behaviour; p=0.171 for survey score) revealed that the rate of children's negative behaviour and the total survey score followed a normal distribution. However, because the sample size was relatively small and the rate of negative behaviour was approaching a non-normal distribution, it was considered appropriate to use a more conservative non-parametric test to analyse the data.

9.3 Results

The Spearman's rank-order correlation test revealed a negative association, which is statistically significant, for the rate of children's negative behaviour and the mean group survey score (r_s=-0.552; p=0.001). As survey score increased, the rate of negative behaviour decreased (Figure 9.1).

Table 9.1. Details of the groups that were included in this part of the research.

ID	Tour or camp	Fota or Dingle	Condition
DS143	Tour	Dingle	Control
DS144	Tour	Dingle	Control
DS151	Tour	Dingle	Control
DS153	Tour	Dingle	Control
DS154	Tour	Dingle	Control
DS161	Tour	Dingle	Control
DS141	Tour	Dingle	Treatment
DS142	Tour	Dingle	Treatment
DS152	Tour	Dingle	Treatment
DS155	Tour	Dingle	Treatment
DS156	Tour	Dingle	Treatment
DS162	Tour	Dingle	Treatment
FS149	Tour	Fota	Control
FS152	Tour	Fota	Control
FS155	Tour	Fota	Control
FS158	Tour	Fota	Control
FS148	Tour	Fota	Treatment
FS151	Tour	Fota	Treatment
FS153	Tour	Fota	Treatment
FS154	Tour	Fota	Treatment
FS157A	Tour	Fota	Treatment
FS157B	Tour	Fota	Treatment
FS161	Tour	Fota	Treatment
FS162	Tour	Fota	Treatment

Table 9.1 Continued. Details of the groups that were included in this part of the research.

ID	Tour or camp	Fota or Dingle	Condition
FC143	Camp	Fota	Control
FC151	Camp	Fota	Control
FC152	Camp	Fota	Control
FC154	Camp	Fota	Control
FC162	Camp	Fota	Control
FC141	Camp	Fota	Treatment
FC142	Camp	Fota	Treatment
FC144	Camp	Fota	Treatment
FC153	Camp	Fota	Treatment
FC163	Camp	Fota	Treatment

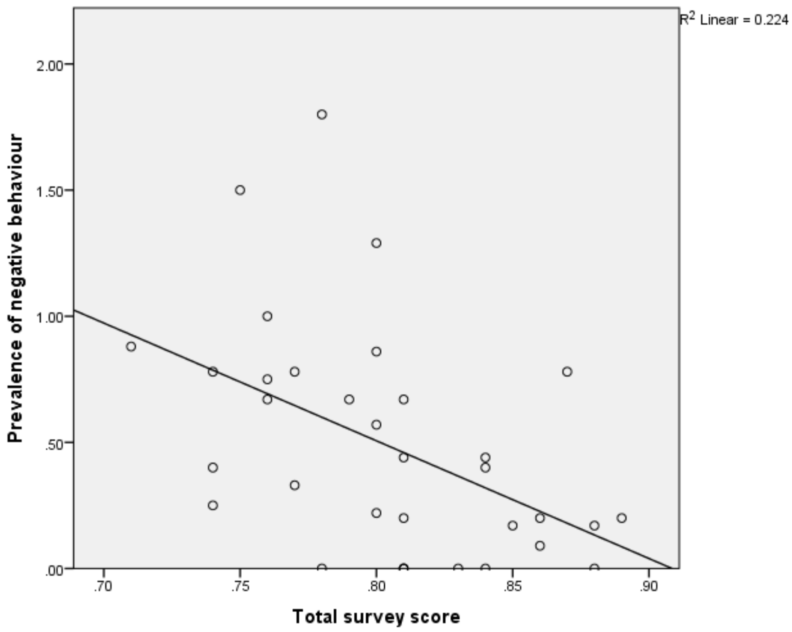


Figure 9.1 The prevalence of negative behaviour by children versus mean survey score for groups at Fota Wildlife Park and Dingle Aquarium with a regression line showing a negative correlation.

9.4 Discussion

The aim of this part of the research was to determine if a relationship exists between knowledge and behaviour. The findings indicate that as the children's survey score increased the rate of negative behaviour as children viewed penguins decreased. However, based on these results it would be inaccurate to say that the zoo visit led to pro-conservation behaviour change because there were still groups that engaged in poor behaviour after the educational experience. Rather, those groups whose knowledge improved after the visit, showed fewer incidences of negative behaviour. These results confirm and build on the research of Ballantyne and Packer (2002) and Bexell et al. (2013), although Ballantyne and Packer (2002) cautioned that many variables contribute to the development of pro-conservation behaviour in students. Bexell et al. (2013) stated that the campers in their study had significant gains in knowledge and reductions in observed negative behaviours. They inferred a connection between increased knowledge of skills to help animals and decreased negative behaviour, yet Bexell et al. (2013) did not specifically test for an association between knowledge and behaviour. Lukas and Ross (2005) also reported a positive association between knowledge and attitude scores on a survey, as knowledge increased, attitude towards apes improved, but behaviour was not measured.

The current research focused on reducing negative behaviour as children view animals to promote positive animal welfare (see Chapter 7). Therefore, it is not possible to say if the children were also inspired to start a new behaviour (e.g. recycling, reducing plastic use) after discussing how ocean pollution affects penguins in the wild. Interestingly, Bexell et al. (2013) also reported a reduction of a negative behaviour because of participation in an EE programme, but results of positive behaviours were less clear. It may be easier to reduce a negative behaviour than start a new positive behaviour. Dierking et al. (2004) asserted that even if an environmental education experience leads to a positive behaviour change, the new behaviours may not persist. However, Dierking et al. (2004) investigated intended behaviour not actual observed behaviours. According to Smith et al. (2008) it is possible that an observed behaviour is more likely to continue than one that is intended, but not yet begun. Regardless, since the current study found that knowledge does last beyond the immediate visit

(Chapter 6 of this thesis) future research should conduct a follow-up study to determine if the reduction of negative behaviour also persists in children.

The study used aggregate group data for both the survey score and the observed behaviour so it is possible that these data are not reflective of all children in the group. There could have been individuals whose negative behaviour increased with an increasing survey score. Associations between knowledge and behaviour for individuals is something that future studies should consider. Additionally, the research concerns post-survey data (after the educational experience) only. If the sample size was larger, a correlation of camp children's knowledge and behaviour before the educational experience could be included to reveal if the connection between knowledge and behaviour is pre-existing, or if it is related to the education received during the zoo visit.

There are many factors that influence conservation-related behaviour (Ballantyne and Packer, 2002; Ham, 2007), including the behaviour that the animals are engaged in as visitors view them (Luebke et al., 2016). Certainly, visitors' emotions and predispositions contribute to visitors' behaviour (Dierking et al., 2004; Luebke and Matiasek, 2013; Luebke et al., 2016), as well as their pre-visit environmental attitude (Ballantyne et al., 2011). While the connection found here between knowledge and behaviour may be too simplistic to predict behaviour in the zoo, it signifies that a significant relationship exists between knowledge and behaviour. If a zoo visit positively influences visitors' behaviour this could ultimately lead to positive conservation outcomes (Smith et al., 2008). However, more research is needed before these data can be generalised. Future research should include a larger sample, at a broader range of institutions, with more observed species to investigate more fully the relationship between knowledge and children's behaviour as they view animals.

9.5 Conclusions

1. A significant negative association was discovered between survey score and observed behaviour. Groups of children who scored higher on the survey were less likely to engage in negative behaviour.

9.6 References

Ajzen, I. (1985). From intentions to actions: A theory of planned behavior. In *Action control* (pp. 11-39). Springer Berlin Heidelberg.

Ajzen, I. (1991). The theory of planned behavior. *Organizational behavior and human decision processes*, 50(2), 179-211.

Ballantyne, R. & Packer, J. (2002). Nature-based excursions: School students' perceptions of learning in natural environments. *International Research in Geographical and Environmental Education*, 11(3), 218–236.

Ballantyne, R., Packer, J. & Falk, J. (2011). Visitors' learning for environmental sustainability: Testing short-and long-term impacts of wildlife tourism experiences using structural equation modelling. *Tourism Management*, *32*(6), 1243-1252.

Bamberg, S. & Moser, G. (2007). Twenty years after Hines, Hungerford, and Tomera: A new meta-analysis of psycho-social determinants of pro-environmental behaviour. *Journal of Environmental Psychology*, 27(1), 14–25.

Bexell, S. M., Jarrett, O. S. & Ping, X. (2013). The effects of a summer camp program in China on children's knowledge, attitudes, and behaviors toward animals: A model for conservation education. *Visitor Studies*, 16(1), 59-81.

Boeve-de Pauw, J. & Van Petegem, P. (2011). The effect of Flemish eco-schools on student environmental knowledge, attitudes, and affect. *International Journal of Science Education*, 33(11), 1513-1538.

Bogner, F. X. (1998). The influence of short-term outdoor ecology education on long-term variables of environmental perspective. *The Journal of Environmental Education*, 29 (4), 17-29.

Borchers, C., Boesch, C., Riedel, J., Guilahoux, H., Ouattara, D. & Randler, C. (2014). Environmental education in Côte d'Ivoire/West Africa: Extra-curricular primary school teaching shows positive impact on environmental knowledge and attitudes. *International Journal of Science Education, Part B*, 4(3), 240-259.

Dierking, L. D., Adelman, L. M., Ogden, J., Lehnhardt, K., Miller, L. & Mellen, J. D. (2004). Using a behavior change model to document the impact of visits to Disney's Animal Kingdom: A study investigating intended conservation action. *Curator: The Museum Journal*, 47(3), 322-343.

Falk, J. H. & Dierking, L.D. (2000). *Learning from Museums: visitor experiences and the making of meaning*. Walnut Creek, CA. Alta Mira Press.

Ham, S. (2007). Can interpretation really make a difference? Answers to four questions from cognitive and behavioral psychology. In *Proceedings, Interpreting World Heritage Conference, March* (pp. 25-29).

Ham, S. H. (2009). From interpretation to protection: Is there a theoretical basis? *Townsville, Queensland, Australia, April 13–17, 2010*, 98.

Hein, G. E. (1998). *Learning in the Museum*. Routledge.

Hines, J. M., Hungerford, H. R. & Tomera, A. N. (1987). Analysis and synthesis of research on responsible environmental behavior: A meta-analysis. *The Journal of Environmental Education*, 18(2), 1-8.

Hungerford, H. R. & Volk, T. L. (1990). Changing learner behavior through environmental education. *The Journal of Environmental Education*, 21(3), 8-22.

Jensen, E. (2011). *Learning about Animals, Science and Conservation at the Zoo: Large-scale survey-based evaluation of the educational impact of the ZSL London Zoo Formal Learning programme.* A report to The Zoological Society of London.

Jensen, E. A., Moss, A. & Gusset, M. (2017). Quantifying long-term impact of zoo and aquarium visits on biodiversity-related learning outcomes. *Zoo Biology*, 36(4), 294-297.

Kuhar, C. W., Bettinger, T. L., Lenhardt, K., Tracy, O. & Cox, D. (2010). Evaluating for long-term impact of an Environmental Education Program at the Kalinzu Forest Reserve, Uganda. *American Journal of Primatology*, 72, 407-413.

Luebke, J. F. & Matiasek, J. (2013). An exploratory study of zoo visitors' exhibit experiences and reactions. *Zoo Biology*, 32(4), 407-416.

Luebke, J. F., Watters, J. V., Packer, J., Miller, L. J. & Powell, D. M. (2016). Zoo Visitors' Affective Responses to Observing Animal Behaviors. *Visitor Studies*, 19(1), 60-76.

Lukas, K. E. & Ross, S. R. (2005). Zoo visitor knowledge and attitudes toward gorillas and chimpanzees. *The Journal of Environmental Education*, 36(4), 33.

Moss, A. & Esson, M. (2013). The Educational Claims of Zoos: Where Do We Go from Here? *Zoo Biology*, 32, 13-18.

Moss, A., Jensen, E. & Gusset, M. (2015). Evaluating the contribution of zoos and aquariums to Aichi Biodiversity Target 1. *Conservation Biology*, 29(2), 537-544.

Myers, O. G. (2007). *The significance of children and animals: Social development and our connections to other species*. West Lafayette, IN: Purdue University Press.

Ogden, J. & Heimlich, J. E. (2009). Why focus on zoo and aquarium education? *Zoo Biology*, 28(5), 357–60.

Smith, L., Broad, S. & Weiler, B. (2008). A closer examination of the impact of zoo visits on visitor behaviour. *Journal of Sustainable Tourism*, 16(5), 544-562.

UNESCO. 1978. Final report: Intergovernmental Conference on Environmental Education, Organized by UNESCO in Cooperation with UNEP, Tbilisi, USSR, October 14–26, 1977, Paris: UNESCO ED/MD/49.

Visscher, N. C., Snider, R. & Vander Stoep, G. (2009). Comparative analysis of knowledge gain between interpretive and fact-only presentations at an animal training session: an exploratory study. *Zoo Biology*, 28(5), 488-495.

Wellington, J. & Szczerbinski, M. (2007). *Research methods for the social sciences*. Continuum International Publishing Group: London and New York.

Chapter 10

General summary and conclusions

10.1 Summary and key findings

The research in this thesis was conducted to explore the relationship between zoological education, zoo visitors and animal behaviour. The study has made a significant contribution to the area of animal behaviour concerning the behavioural response of two under-studied species to visitors and the zoo environment. It represents the first in-depth study of children's zoological education in Ireland. It is also the first study to consider both children's behaviour and the animal's behaviour in detail, as children view animals, while taking into account the effect of education. Furthermore, as part of the research, a purposefully designed, hands-on educational intervention was developed. The thesis is a significant source of information for both zoological institutions and zoo educators in regards to enhancing education and promoting pro-conservation behaviour in visitors at the zoo.

The research began by investigating ring tailed lemurs' (*Lemur catta*) and Gentoo penguins' (*Pygoscelis papua*) response to visitors and the zoo setting (Chapters 3 and 4, Appendix 6). Some of the key findings discovered were:

- The free-ranging ring-tailed lemurs and the Gentoo penguins were largely unaffected by visitors and appeared to have habituated to both visitors and the zoo-setting.
- The few close contact animal-visitor interactions that did occur between visitors and the free-ranging lemurs usually resulted in no response from the lemurs.
- There was evidence that the penguins at Dingle Aquarium appeared to benefit from visitors, since as visitor number increased, overall penguin behavioural diversity increased, particularly pool use.
- There was no evidence that the lemurs or penguins in the study were affected when visitors did not comply with institution rules.
- Both the ring-tailed lemurs and the Gentoo penguins included in this study appeared to have high 'educational potential' and could be suitable in a controlled environment for animal-visitor interactive experiences.

Next, the research investigated children's learning in the zoo through the use of pre- and post-surveys (Chapters 5 and 6). Some of the key findings included:

- The study discovered increases in knowledge and behaviour for all groups, but generally, the most significant and consistent predictor of knowledge and behaviour score increase was participation in the educational intervention.
- The results showed that the type of institution involved is significant and suggests that the naturalistic environment at Fota better promoted learning.
- Camp children arrived with higher knowledge and behaviour scores than school tour children. However, school tour children were more likely to gain in knowledge whereas camp children were more likely to experience increases in behaviour score between pre- and post-survey.
- A six-month follow-up study showed that knowledge persisted after the visit to Dingle Aquarium, but in this case the control groups were more likely than the treatment groups to experience an increase in knowledge and behaviour score.
- Generally, little change was detected in students' attitude score.

Unique to the current study, the children's behaviour and conversation and animals' behaviour were observed simultaneously when the children viewed the animals (Chapters 7 and 8). Finally, the research considered the relationship between knowledge and behaviour (Chapter 9). Some of the key findings from this section of the research were:

- Children who had participated in the educational intervention displayed fewer negative behaviours than those who only experienced the standard curriculum. This was consistent for all three species of captive animal and both institutions. This significant finding demonstrates that observable, on-site, pro-conservation behaviour change with children is possible in the zoo setting (Hungerford and Volk, 1990; Smith et al., 2008).
- Children in the treatment group also made more positive and fewer negative comments than those in the control group, while viewing the animals.

- There was little difference in the animals' behaviour when either control or treatment groups were present.
- Groups who scored higher on the survey were less likely to engage in negative behaviour as they viewed animals.

These findings highlight the significant contribution of the educational intervention on children's learning at Fota Wildlife Park and Dingle Aquarium. Furthermore, the mixed-method approach to data collection (Jensen, 2011) allows for confidence in the results, which consistently show, regardless of the data collection technique, that the educational intervention enhanced learning. Of course, it was challenging to include both children and animals in one research project, and the development and implementation of the methodology represents a balance of what was theoretically desirable, but also practically possibly (A. Moss, Chester Zoo, pers. comm. 2013). Therefore, this study can be useful in shaping future zoological education research and also research on free-ranging species, by expanding upon techniques and methodologies used in the current study. Several recommendations, based on the results discovered in this project are outlined in section 10.2.

10.2 Recommendations

- Future research should further investigate the species included here, at other institutions, under more conditions to see if results can be generalised, and to increase the sample size.
- More work quantifying the effects of interactive experiences on both the visitors who participate in the experiences and the animals that are used during them needs to be carried out, including a range of different experiences and species. Preferably this should include simultaneous observation of both visitors and animals.
- It would be particularly useful to include more studies on free-ranging animals, or even animals, similar to the penguins at Fota, that are kept in a naturalistic enclosure but can experience close-contact with visitors. Despite the increasing popularity of keeping animals this way, there is little published research on animal-visitor interactions in a free-range setting. Additionally, directionality

of animal behaviour when large numbers of visitors are present should be more fully explored to more clearly understand the animals' behaviour.

- This was one of the first studies to consider if education in the zoo setting might result in a quantifiable biological impact in the zoo (improved animal welfare). Although that was not detected here, future researchers could build upon this idea to expand the current understanding of the impact of zoological education.
- The children in this study benefitted from the educational intervention, though at times it was difficult to disentangle exactly which part of the programme was beneficial. Future research should focus on specific points (e.g. the hands-on activity or observing animals with enrichment) in order to more fully understand the effect of education on visitors' learning and behaviour.

- The educational intervention was associated with a quantifiable improvement in children's behaviour at both institutions as they viewed the animals. It is likely that this was directly related to the discussion about visitor effects that occurred during the EI. While it may not be feasible to include every visitor in a discussion, certainly zoo staff could be trained to engage visitors in discussion about their potential effect on the animals, especially if the animals are known to suffer stress from negative visitor behaviour or are exposed to intense visitor interactions. For example, at Fota Wildlife Park, where lemur patrol staff keep visitors from coming too close to the lemurs, they could also discuss visitor effects. Also, many zoological institutions have 'keeper talks,' discussions about visitor effects could be incorporated into these presentations. Certainly, groups that come to zoos and aquariums for scheduled tours could participate in a brief discussion on their potential effect on the animals. However, since Jens et al. (2012) caution that despite communication with the public about free-ranging primates, negative interactions still occurred, the animals should continue to be carefully monitored.
- Providing a range of hands-on activities for visitors could facilitate visitor enjoyment, education and potentially animal welfare. Since zoos must balance these three complex goals, controlled, supervised and limited activities could be a solution to this long-term dilemma (Fernandez et al., 2009). Simple activities like food preparation and making uncomplicated enrichment devices could be

easily implemented and are financially viable for zoos. In addition to already existing programmes at Fota Wildlife Park like the ‘warden experience,’ ‘VIP family experience,’ and ‘behind the scenes,’ at certain times, tables could be set up where visitors (with gloves) could prepare food and enrichment for the animals.

- Visitors seek interactions and reactions from captive animals (Kreger and Mench, 1995), and under strict supervision, more intense interactive events like distributing lemurs’ scatter feed or giving penguins enrichment could help zoos achieve their stated goals.
- While the current research was limited to school children, the educational intervention, specifically the design and implementation of enrichment for the animals, could be extended to adults and family groups on a more permanent basis.

10.3 Conclusions

Ultimately, this research has shown that the animal species included in this study were not negatively affected by visitors even when interactions involved close encounters or visitors behaved poorly towards the animals. This research is one of the first studies to quantifiably show that visitors learned more from direct interaction with the animals. Children in the treatment group, who were able to engage with the animals through the development and implementation of an enrichment device consistently had increased survey scores, made more positive comments indicative of learning and showed improved behaviour, compared to those who did not participate in the class. Thus, one of the major goals of environmental education – behaviour change – was achieved (Hungerford and Volk, 1990). Disappointingly, the introduction of the enrichment and the improved visitor behaviour did not lead to a positive change in the animals’ behaviour, which could have indicated improved welfare. However, and importantly, the close proximity of the children’s groups and their introduced enrichment did not induce a negative change in the animals’ behaviour.

Interactive animal-visitor programmes in zoos already exist and are becoming increasingly popular. However, to date only limited peer-reviewed evidence of the impact of these experiences exists, with varying results (Szokalski et al., 2013; Jones et al., 2016). More research is needed in this area since caution must always be applied when bringing the general public into contact with wild animals. While incidences of animal attacks in the zoo are rare, unfortunately at least two attacks during visitor interactive sessions have occurred and extreme caution should be applied with certain species (Hosey and Melfi, 2015). Neither species included in the current study are known to be involved in a serious attack on a member of the public. Even so, in the current study no close-contact occurred between the animals and the children. However, Fota Wildlife Park and Dingle Aquarium can now state with confidence that 1) the animals included in this study did not show an adverse reaction to visitors and are therefore suitable for controlled interactive experiences and 2) children not only learned more from hands-on activity, but also showed improved behaviour.

This study represents a first step towards an understanding of the complex relationship between education, zoo visitors and animal behaviour. Zoos are in a unique position to educate the public about environmental issues (Patrick and Tunnicliffe, 2012; Moss et al., 2015), and this thesis has shown that learning does occur in the zoo setting. Yet, even if zoos are achieving their aims to be educators, they may struggle to balance all of their stated goals, namely education, animal welfare, entertainment, research and conservation (Hosey, 2005; Fernandez et al., 2009). However, the current research has discovered that these goals are not incompatible in the zoo setting. The extensive evidence presented here shows that zoos are a suitable medium for learning, and that when coupled with a hands-on interactive experience with animals, who have habituated to visitor presence, learning was enhanced and the efficacy of the zoos' education programme was improved.

10.4 References

Fernandez, E. J., Tamborski, M. A., Pickens, S. R. & Timberlake, W. (2009). Animal-visitor interaction in the modern zoo: conflicts and interventions. *Applied Animal Behaviour Science*, 120, 1-8.

Hosey, G. R. (2005). How does the zoo environment affect the behaviour of captive primates? *Applied Animal Behaviour Science,* 90, 107-129.

Hosey, G. & Melfi, V. (2015). Are we ignoring neutral and negative human–animal relationships in zoos? *Zoo Biology*, *34*(1), 1-8.

Hungerford, H. R. & Volk, T. L. (1990). Changing learner behavior through environmental education. *The Journal of Environmental Education*, 21(3), 8-22.

Jens, W., Mager-Melicharek, C. A. X. & Rietkerk, F. E. (2012). Free-ranging New World primates in zoos: cebids at Apenheul. *International Zoo Yearbook*, 46(1), 137-149.

Jensen, E. (2011). *Learning about Animals, Science and Conservation at the Zoo: Large-scale survey-based evaluation of the educational impact of the ZSL London Zoo Formal Learning programme*. A report to The Zoological Society of London.

Jones, H., McGregor, P. K., Farmer, H. L. A. & Baker, K. R. (2016). The influence of visitor interaction on the behavior of captive crowned lemurs (*Eulemur coronatus*) and implications for welfare. *Zoo Biology*, 35(3), 222-227.

Kreger, M. D. & Mench, J. A. (1995). Visitor–animal interactions at the zoo. *Anthrozoös*, 8, 143–158.

Moss, A., Jensen, E. & Gusset, M. (2015). Evaluating the contribution of zoos and aquariums to Aichi Biodiversity Target 1. *Conservation Biology*, 29(2), 537-544.

Patrick, P. G. & Tunnicliffe, S. D. (2012). *Zoo talk*. Springer Science & Business Media.

Smith, L., Broad, S. & Weiler, B. (2008). A closer examination of the impact of zoo visits on visitor behaviour. *Journal of Sustainable Tourism*, 16(5), 544-562.

Szokalski, M. S., Foster, W. K. & Litchfield, C. A. (2013). Behavioral monitoring of big cats involved in 'behind-the-scenes' zoo visitor tours. *International Journal of Comparative Psychology*, *26*(1), 83-104.

Appendices

Appendix 1: Supplemental data

Tables show group results obtained during the study.

For all tables, the data are presented in order of experimental condition and then lowest to highest survey difference (Diff.) score. Questionnaire score is presented as the group average. It includes results for all attitude and behaviour questions on the survey, but only includes knowledge questions pertaining to the species listed in the table. Conversation data are represented as the proportion of positive and negative comments made by each group or the 'diversity of conversation.' Incidence of negative behaviour are presented as rate per minute. NA = data that were not used because they did not fit the parameters of the study.

Table A2.1. Fota Wildlife Park school tour group results at the ring-tailed lemurs.

School ID	Experimental condition	Questionnaire score			Conversational content		Negative behaviour
		Pre	Post	Diff.	Positive	Negative	
FS155	Control	0.76	0.76	0.00	NA	NA	NA
FS149	Control	0.75	0.79	+0.04	0.50	0.00	0.40
FS152	Control	0.69	0.76	+0.07	NA	NA	NA
FS148	Treatment	0.69	0.81	+0.12	0.79	0.00	0.00
FS154	Treatment	0.71	0.84	+0.13	NA	NA	NA
FS151	Treatment	0.64	0.78	+0.14	NA	NA	NA
FS153	Treatment	0.70	0.87	+0.17	NA	NA	NA

Table A2.2. Fota Wildlife Park camp group results at the ring-tailed lemurs.

Camp ID	Experimental condition	Questionnaire score			Conversational content				Negative behaviour	
					Positive		Negative			
		Pre	Post	Diff.	Pre	Post	Pre	Post	Pre	Post
FC154	Control	0.82	0.79	-0.03	0.43	0.57	0.25	0.25	0.29	0.00
FC131	Control	0.91	0.90	-0.01	NA	NA	NA	NA	0.88	0.29
FC151	Control	0.85	0.85	0.00	0.64	0.57	0.25	0.25	0.27	0.33
FC162	Control	0.75	0.81	0.06	0.50	NA	0.25	NA	0.25	NA
FC143	Control	0.76	0.83	0.07	0.79	0.43	0.25	0.25	0.20	0.25
FC152	Control	0.74	0.81	0.07	0.50	0.57	0.00	0.50	0.00	0.00
FC144	Treatment	0.85	0.86	0.01	0.50	0.64	0.25	0.25	0.20	0.00
FC153	Treatment	0.82	0.86	0.04	0.50	0.79	0.25	0.25	0.67	0.17
FC161	Treatment	0.80	0.87	0.07	0.71	NA	0.25	NA	0.00	NA
FC142	Treatment	0.78	0.86	0.08	0.50	0.79	0.25	0.00	0.17	0.00
FC141	Treatment	0.75	0.84	0.09	0.64	0.36	0.50	0.25	0.00	0.00
FC163	Treatment	0.73	0.85	0.12	0.36	0.64	0.00	0.25	0.00	0.00

Table A2.3. Fota Wildlife Park school tour group results at the Humboldt penguins.

School ID	Experimental condition	Questionnaire score			Conversational content		Negative behaviour
		Pre	Post	Diff.	Positive	Negative	
FS163	Control	NA	NA	NA	0.29	0.50	0.50
FS142	Control	NA	NA	NA	0.36	0.25	0.50
FS146/7	Control	NA	NA	NA	0.36	0.50	0.80
FS155	Control	0.75	0.75	0.00	0.36	0.25	1.00
FS149	Control	0.75	0.77	0.02	NA	NA	NA
FS158	Control	0.02	0.02	0.08	0.21	0.75	0.75
FS152	Control	0.71	0.77	0.06	NA	NA	NA
FS141	Treatment	NA	NA	NA	0.64	0.00	0.25
FS145	Treatment	NA	NA	NA	0.57	0.00	0.15
FS156A	Treatment	NA	NA	NA	0.64	0.00	0.00
FS156B	Treatment	NA	NA	NA	0.57	0.00	0.00
FS162	Treatment	0.68	0.74	0.06	0.43	0.25	0.25
FS161	Treatment	0.74	0.83	0.09	0.36	0.00	0.00
FS154	Treatment	0.60	0.71	0.11	0.79	0.00	0.00
FS157A	Treatment	0.71	0.82	0.11	0.50	0.00	0.00
FS157B	Treatment	0.71	0.82	0.11	0.43	0.00	0.00
FS148	Treatment	0.69	0.83	0.14	NA	NA	NA
FS151	Treatment	0.02	0.02	0.14	0.57	0.50	0.67
FS153	Treatment	0.71	0.87	0.16	0.64	0.25	0.20

Table A2.4. Fota Wildlife Park camp group results at the Humboldt penguins.

Camp ID	Experimental condition	Questionnaire score			Conversational content				Negative behaviour	
					Positive		Negative			
		Pre	Post	Diff.	Pre	Post	Pre	Post	Pre	Post
FC154	Control	0.82	0.79	-0.03	NA	NA	NA	NA	NA	NA
FC151	Control	0.83	0.86	0.03	0.29	0.21	0.00	0.25	0.25	0.40
FC162	Control	0.75	0.81	0.06	0.29	0.43	0.50	0.25	1.33	0.86
FC152	Control	0.75	0.81	0.06	0.14	0.21	0.00	0.25	0.33	0.00
FC143	Control	0.73	0.81	0.08	0.36	0.29	0.25	0.25	1.00	0.67
FC144	Treatment	0.89	0.87	-0.02	NA	NA	NA	NA	NA	NA
FC153	Treatment	0.81	0.87	0.06	0.21	0.57	0.25	0.00	0.33	0.17
FC161	Treatment	0.80	0.86	0.06	NA	NA	NA	NA	NA	NA
FC142	Treatment	0.79	0.86	0.07	0.36	0.36	0.25	0.00	0.57	0.20
FC163	Treatment	0.73	0.85	0.12	0.21	0.57	0.25	0.00	0.29	0.17
FC141	Treatment	0.73	0.86	0.13	0.29	0.43	0.25	0.25	0.13	0.09

Table A2.5. Dingle Aquarium school tour group results

School ID	Experimental condition	Questionnaire score			Conversational content		Negative behaviour
		Pre	Post	Diff.	Positive	Negative	
DS145	Control	NA	NA	NA	0.29	0.25	1.29
DS153	Control	0.75	0.71	-0.04	0.50	0.50	0.88
DS154	Control	0.74	0.74	0.00	0.36	0.00	0.40
DS143	Control	0.73	0.75	+0.02	0.57	0.25	1.50
DS144	Control	0.78	0.80	+0.02	0.50	0.00	1.29
DS161	Control	0.72	0.74	+0.02	0.50	0.50	0.78
DS151	Control	0.74	0.78	+0.04	0.43	0.25	1.80
DS141	Treatment	0.75	0.77	+0.02	0.64	0.00	0.78
DS152	Treatment	0.77	0.80	+0.03	0.57	0.00	0.22
DS162	Treatment	0.75	0.81	+0.06	0.64	0.00	0.44
DS155	Treatment	0.73	0.80	+0.07	0.64	0.00	0.57
DS156	Treatment	0.77	0.84	+0.07	0.64	0.00	0.44
DS142	Treatment	0.79	0.87	+0.08	0.79	0.25	0.78

Appendix 2: Additional data not used in the analysis

Tables show data that were excluded from parts of the study and the corresponding reason.

Not all the data collected during the study were useable for each section because they did not fit within the stated parameters of the study. Scheduling, weather, variation in animal behaviour and age of participants were the main causes for data being excluded from observation or suvey analysis.

Table A3.1. Data excluded from the observation of ring-tailed lemurs at Fota school tours.

Group excluded from the study Lemurs school tour FWP	Reason
FS151 and FS152	The lemurs were located on the roof of a building and would not come down. The children still saw them, but there was no opportunity for interaction and it was difficult to observe the lemurs' behaviour. Therefore, the children's behaviour and conversation and the animals' behaviour were not included for these groups.
FS153, FS154 and FS155	Fota staff were unable to arrive in time to meet the school group with the scatter feed. This may have altered the lemurs' behaviour. Therefore, the animals' behaviour and the children's behaviour and conversation were excluded.

Table A3.1. Data excluded from the observation of ring-tailed lemurs at Fota camps.

Group excluded from the study Lemurs camp FWP	Reason
FC131 (pre/post)	There was no conversation data recorded for this camp because the methodology was still being developed.
FC161 (post)	There was no 'post' observation session for this camp due to very heavy rain. Therefore, the lemurs were not observed and the children's behaviour and conversation could not be recorded.
FC162 (post)	There was no scatter feed delivered when the children arrived to view the lemurs for the 'post' session. Therefore, the animals' behaviour, children's behaviour and children'sconversation were excluded.

Table A3.3. Data excluded from the observation of Humboldt penguins at Fota school tours.

Group excluded from the study Humboldt penguins school tour FWP	Reason
FS141, FS142, FS145, FS146/7 FS156A, FS156B, FS163	The children at that participated in these groups were too young to complete the survey (8 years and younger). One group was a special needs school and they did not complete the survey. However, animals' behaviour and children's behaviour and conversation were observed and recorded.
FS148, FS149 and FS152	When these groups arrived at the penguin enclosure the penguins were either in the process of being fed or had just been fed. The animals' behaviour was altered because of this. Therefore, the animals' behaviour, children's behaviour and conversation were excluded.

Table A3.4. Data excluded from the observation of Humboldt penguins at Fota camps.

Group excluded from the study Humboldt penguins camp FWP	Reason
FC154 (pre/post) and FC144 (pre/post)	Since it was outside of the penguins' breeding season, penguin behaviour data was excluded. Therefore, children's conversation and behaviour were also excluded. Children still observed the penguins.
FC161 (pre/post)	Pre: Fota staff did not have time to take the children to see the penguins as part of the tour. Therefore, there were no data recorded for this session. Post: It was raining heavily. Children were taken by train to see the penguins, but the data were not used for the penguins or the children.

Table A3.5. Data excluded from the observation of Gentoo penguins at Dingle school tours.

Group excluded from the study Gentoo penguins tour DA	Reason
DS145	The children in this group were too young to complete the survey (8 years and younger).

Appendix 3: Surveys

Surveys administered during the course of the research.

1. The pre-survey administered before visiting Fota Wildlife Park on a school tour.

2. The post-survey administered after visiting Fota Wildlife Park on a school tour.

3. The pre-survey administered before visiting Dingle Aquarium on a school tour.

4. The post-survey administered after visiting Dingle Aquarium on a school tour.

5. The pre-survey administered before the Fota Wildlife Park camp.

6. The post-survey administered after the Fota Wildlife camp.

7. The post-2-survey administered six months after visiting Dingle Aquarium.

1. The pre-survey administered before visiting FWP on a school tour.

First Name:_________________ Second Name:__________________________

Age: **Gender – Please circle**: Boy Girl

* * *

1. Have you ever visited a zoo before today?

Yes No I'm not sure

2. Do you like to watch nature shows on TV?

Yes No I'm not sure

3. What is your favourite subject at school?

4. How can you help animals living in zoos? Please answer with ONE idea in the box.

* * *

Please read each sentence below. Circle the answer that most closely matches how you feel.

5. Zoo animals are HAPPY.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

6. Zoo animals are BORED.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

7. During my visit to Fota, I am looking forward to LEARNING ABOUT ANIMALS.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

8. During my visit to Fota, I am looking forward to LEARNING SCIENCE.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

9. When you think of Fota Wildlife Park, what is the first thing that comes to mind? One word

In this section, if you don't know the answer, just take a guess. Choose one answer only.

***10. Ring-tailed lemurs come from...?**

Africa South America Madagascar New Zealand Sri Lanka

***11. Ring-tailed lemurs are endangered because of...?**

Drought Deforestation Global Warming Fire Hunting

***12. What do you think is the most important part of a Ring-tailed Lemur's diet?**

Fruit Flowers Leaves Food from visitors Meat

* * *

13. Do you think penguins are?

Marine mammals Birds Fish I'm not sure

14. Do you think penguins can fly?

Yes I'm not sure No

15. Where do you think penguins live (mostly)?

The Northern Hemisphere The Southern Hemisphere Both I'm not sure

16. Do you think penguins live in ...

Warm places Cold places Both I'm not sure

* * *

Some animals at Fota live in enclosures and some are free-ranging, which means they can walk around the park. Some zoo animals have enrichment (toys), which promotes more natural behaviour.

Please read each statement below and circle the answer that most closely matches how you feel.

17. I think visitors should be allowed to feed free-ranging animals.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

18. I think visitors should be allowed to touch the free-ranging animals.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

19. I like to see zoo animals that have enrichment.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

Thank you! ☺

*Note: After 2015 the lemur questions were excluded from the survey, the EI and the children did not view them while on tour at Fota.

2. The post-survey administered after visiting FWP on a school tour.

First Name:_________________ Second Name:__________________________

* * *

1. Did you enjoy the day at Fota?

Yes No I'm not sure

2. What was the best part?

3. What is your favourite subject at school?

4. How can you help animals living in zoos? Please answer with one idea in the box.

* * *

Please read each sentence below. Circle the answer that most closely matches how you feel.

5. Zoo animals are HAPPY.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

6. Zoo animals are BORED.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

7. During my visit to Fota, I enjoyed LEARNING ABOUT ANIMALS.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

8. During my visit to Fota, I enjoyed LEARNING SCIENCE.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

* * *

9. When you think of Fota Wildlife Park, what is the first thing that comes to mind? One word.

In this section, if you don't know the answer, just take a guess.

***10. Ring-tailed lemurs come from...?**

Africa South America Madagascar New Zealand Sri Lanka

***11. Ring-tailed lemurs are endangered because of...?**

Drought Deforestation Global Warming Fire Hunting

***12. What do you think is the most important part of a Ring-tailed Lemur's diet?**

Fruit Flowers Leaves Food from visitors Meat

* * *

13. Do you think penguins are?

Marine mammals Birds Fish I'm not sure

14. Do you think penguins can fly?

Yes I'm not sure No

15. Where do you think penguins live (mostly)?

The Northern Hemisphere The Southern Hemisphere Both I'm not sure

16. Do you think penguins live in ...

Warm places Cold places Both I'm not sure

* * *

Some animals at Fota live in enclosures and some are free-ranging, which means they can walk around the park. Some zoo animals have enrichment (toys), which promotes more natural behaviour.

Please read each statement below and circle the answer that most closely matches how you feel.

17. I think visitors should be allowed to feed the free-ranging animals.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

18. I think visitors should be allowed to touch the free-ranging animals.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

19. I like to see zoo animals that have enrichment.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

Thank you! ☺

*Note: After 2015 the lemur questions were excluded from the survey, the EI and the children did not view them while on tour at Fota.

3. The pre-survey administered before visiting DA on a school tour.

First Name:__________________ Second Name:____________________________

Age: ____________ Boy/Girl

1. Have you ever visited an aquarium before today?

Yes No I'm not sure

2. Have you ever been to Dingle Aquarium before?

Yes No I'm not sure

3. Do you like to watch nature shows on TV?

Yes No I'm not sure

4. What is your favourite subject at school?

5. How can you help animals that live in aquariums? Please answer with one idea in the box.

Please read each sentence below. Circle the answer that most closely matches how you feel.

6. Aquarium animals are HAPPY

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

7. Aquarium animals are BORED

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

8. During my visit to Dingle Aquarium, I am looking forward to LEARNING ABOUT ANIMALS

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

9. During my visit to Dingle Aquarium, I am looking forward to LEARNING SCIENCE

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

10. When you think of Dingle Aquarium, what is the first thing that comes to mind?

One Word

In this section, if you don't know the answer, just take a guess.

11. Do you think penguins are?

Marine mammals Birds Fish I'm not sure

12. Do you think penguins can fly?

Yes No I'm not sure

13. Where do you think penguins live (mostly)?

The Northern Hemisphere The Southern Hemisphere Both I'm not sure

14. Do you think penguins live in ...

Warm places Cold places Both I'm not sure

* * *

Some aquarium animals have enrichment (toys), which helps to promotes more natural behaviour. Please read each statement below and circle the answer that most closely matches how you feel.

15. I prefer to see aquarium animals that have enrichment.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

16. I think it is okay to bang on the glass at the aquarium to get the animals' attention.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

Thank you! ☺

4. The post-survey administered after visiting DA on a school tour.

First Name:_________________ Second Name:__________________________

1. Did you enjoy the day at Dingle Aquarium?

Yes No I'm not sure

2. What was the best part?

3. What is your favourite subject at school?

4. How can you help animals that live in aquariums? Please answer with one idea in the box.

Please read each sentence below. Circle the answer that most closely matches how you feel.

5. Aquarium animals are HAPPY

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

6. Aquarium animals are BORED

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

7. During my visit to Dingle Aquarium, I enjoyed LEARNING ABOUT ANIMALS

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

8. During my visit to Dingle Aquarium, I enjoyed LEARNING SCIENCE

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

9. When you think of Dingle Aquarium, what is the first thing that comes to mind?

ONE Word

In this section, if you don't know the answer, just take a guess.

10. Do you think penguins are?

Marine mammals Birds Fish I'm not sure

11. Do you think penguins can fly?

Yes No I'm not sure

12. Where do you think penguins live (mostly)?

The Northern Hemisphere The Southern Hemisphere Both I'm not sure

13. Do you think penguins live in ...

Warm places Cold places Both I'm not sure

* * *

Some aquarium animals have enrichment (toys), which helps to promotes more natural behaviour. Please read each statement below and circle the answer that most closely matches how you feel.

14. I prefer to see aquarium animals that have enrichment.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

15. I think it is okay to bang on the glass at the aquarium to get the animals' attention.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

Thank you! ☺

5. The pre-survey administered before the FWP camp.

First Name:_________________ Second Name:__________________________

Age: **Gender – Please circle**: Boy Girl

* * *

1. Have you ever visited a zoo before today?

Yes No I'm not sure

2. Have you ever been to a camp at Fota before?

Yes No I'm not sure

3. Do you like to watch nature shows on TV?

Yes No I'm not sure

4. What is your favourite subject at school?

5. How can you help animals living in zoos? Please answer with ONE idea in the box.

Please read each sentence below. Circle the answer that most closely matches how you feel.

6. Zoo animals are HAPPY.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

7. Zoo animals are BORED.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

8. During my visit to Fota, I am looking forward to LEARNING ABOUT ANIMALS.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

9. During my visit to Fota, I am looking forward to LEARNING SCIENCE.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

* * *

10. When you think of Fota Wildlife Park, what is the first thing that comes to mind?

One Word

In this section, if you don't know the answer, just take a guess.

11. Ring-tailed lemurs come from...?

Africa South America Madagascar New Zealand Sri Lanka

12. Ring-tailed lemurs are endangered because of...?

Drought Deforestation Global Warming Fire Hunting

13. What do you think is the most important part of a Ring-tailed Lemur's diet?

Fruit Flowers Leaves Food from visitors Meat

14. Do you think penguins are?

Marine mammals Birds Fish I'm not sure

15. Do you think penguins can fly?

Yes I'm not sure No

16. Where do you think penguins live (mostly)?

The Northern Hemisphere The Southern Hemisphere Both I'm not sure

17. Do you think penguins live in ...

Warm places Cold places Both I'm not sure

* * *

Some animals at Fota live in enclosures and some are free-ranging, which means they can walk around the park. Some zoo animals have enrichment (toys), which promotes more natural behaviour.

Please read each statement below and circle the answer that most closely matches how you feel.

18. I think visitors should be allowed to feed free-ranging animals.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

19. I think visitors should be allowed to touch the free-ranging animals.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

20. I like to see zoo animals that have enrichment.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

Thank you! ☺

6. The post-survey administered after the FWP camp.

First Name:__________________ Second Name:____________________________

* * *

1. Have you enjoyed the camp at Fota?

Yes No I'm not sure

2. What was the best part?

3. What is your favourite subject at school?

4. How can you help animals living in zoos? Please answer with one idea in the box.

Please read each sentence below. Circle the answer that most closely matches how you feel.

5. Zoo animals are HAPPY.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

6. Zoo animals are BORED.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

7. During my visit to Fota, I enjoyed LEARNING ABOUT ANIMALS.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

8. During my visit to Fota, I enjoyed LEARNING SCIENCE.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

* * *

9. When you think of Fota Wildlife Park, what is the first thing that comes to mind? One Word

In this section, if you don't know the answer, just take a guess.

10. Ring-tailed lemurs come from...?

Africa South America Madagascar New Zealand Sri Lanka

11. Ring-tailed lemurs are endangered because of...?

Drought Deforestation Global Warming Fire Hunting

12. What do you think is the most important part of a Ring-tailed Lemur's diet?

Fruit Flowers Leaves Food from visitors Meat

13. Do you think penguins are?

Marine mammals Birds Fish I'm not sure

14. Do you think penguins can fly?

Yes I'm not sure No

15. Where do you think penguins live (mostly)?

The Northern Hemisphere The Southern Hemisphere Both I'm not sure

16. Do you think penguins live in ...

Warm places Cold places Both I'm not sure

* * *

Some animals at Fota live in enclosures and some are free-ranging, which means they can walk around the park. Some zoo animals have enrichment (toys), which promotes more natural behaviour.

Please read each statement below and circle the answer that most closely matches how you feel.

17. I think visitors should be allowed to feed the free-ranging animals.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

18. I think visitors should be allowed to touch the free-ranging animals.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

19. I like to see zoo animals that have enrichment.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

Thank you! ☺

7. The post-2-survey administered six months after visiting DA.

First Name:_________________ Second Name:__________________________

1. Do you remember your visit to Dingle Aquarium?

Yes No I'm not sure

2. What was the best part?

3. What is your favourite subject at school?

4. How can you help animals that live in aquariums? Please answer with one idea in the box.

Please read each sentence below. Circle the answer that most closely matches how you feel.

5. Aquarium animals are HAPPY

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

6. Aquarium animals are BORED

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

7. During my visit to Dingle Aquarium, I enjoyed LEARNING ABOUT ANIMALS

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

8. During my visit to Dingle Aquarium, I enjoyed LEARNING SCIENCE

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

9. When you think of Dingle Aquarium, what is the first thing that comes to mind?

ONE Word

In this section, if you don't know the answer, just take a guess.

10. Do you think penguins are?

Marine mammals Birds Fish I'm not sure

11. Do you think penguins can fly?

Yes No I'm not sure

12. Where do you think penguins live (mostly)?

The Northern Hemisphere The Southern Hemisphere Both I'm not sure

13. Do you think penguins live in ...

Warm places Cold places Both I'm not sure

* * *

Some aquarium animals have enrichment (toys), which helps to promotes more natural behaviour. Please read each statement below and circle the answer that most closely matches how you feel.

14. I prefer to see aquarium animals that have enrichment.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

15. I think it is okay to bang on the glass at the aquarium to get the animals' attention.

Strongly Agree Agree I'm not sure Disagree Strongly Disagree

Thank you! ☺

Appendix 4: PowerPoint presentations

PowerPoint presentations delivered during the EI.

1. PowerPoint presentation used for the EI at Fota Wildlife Park tours and camps.

2. PowerPoint presentation used for EI at Dingle Aquarium.

1. PowerPoint presentation used for the EI at FWP tours and camps.

Slide 1

Slide 2*

Slide 3*

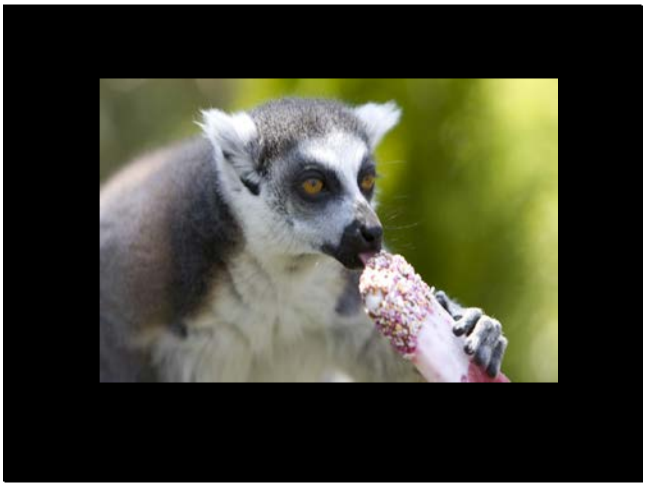
Slide 4*

Slide 5*

Slide 6*

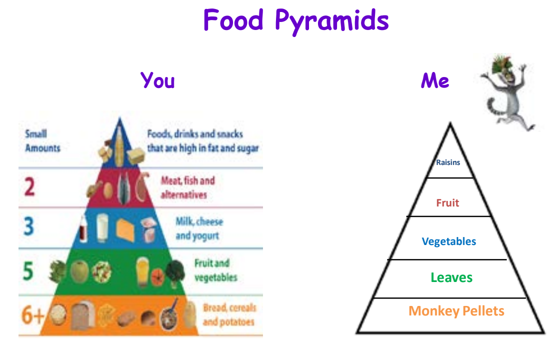
Slide 7*

Slide 8*



Slide 9*

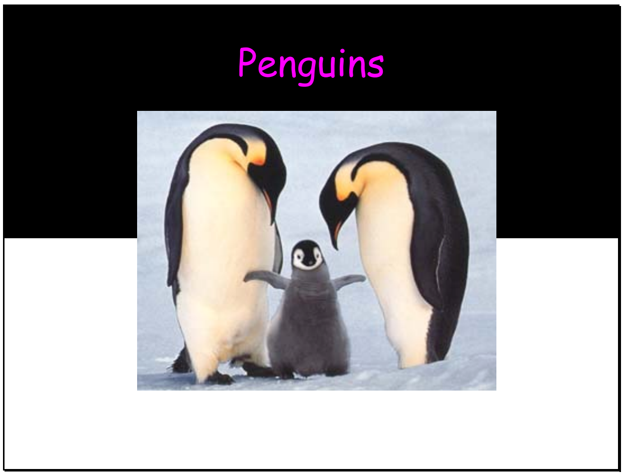
Slide 10*



Slide 11*

Slide 12*

Slide 13



Slide 14

Slide 15

Where do we live?

The Southern Hemisphere

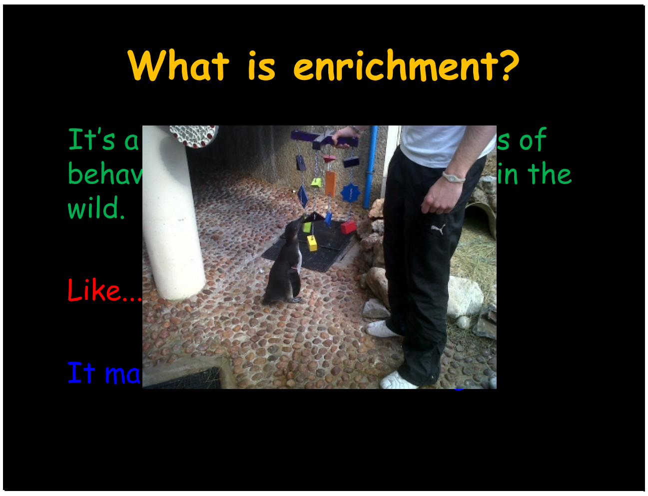
Slide 16

What's the weather like?

Slide 17

Slide 18

Slide 19



Slide 20

Slide 21

Slide 22

Science

is all around you at the zoo!

Slide 23

Let's be real scientists

Can you . . . ?

- Knowledge/Observation
- Make a hypotheses – QUESTION
- Experiment
- Discuss/Report what happened and why

Slide 24

Would you like to help make some enrichment devices for the animals at Fota?

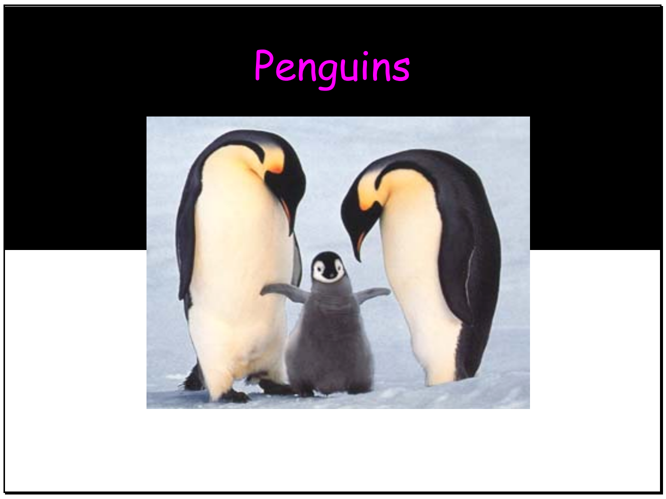
Slide 25

*Note these slides were excluded from the EI after 2015 for school tours only.

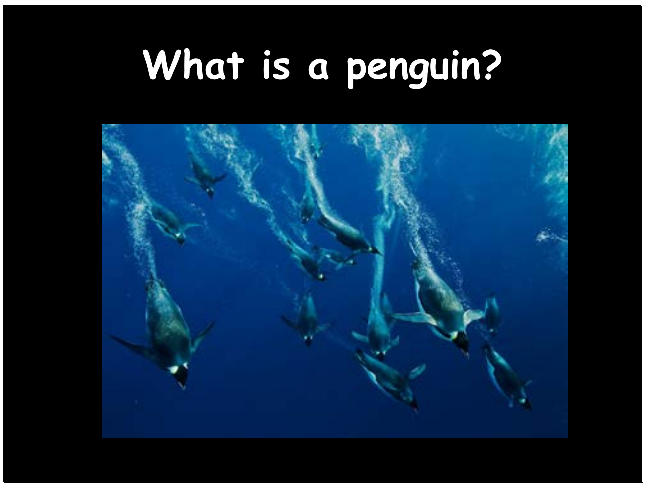
2. PowerPoint presentation used for EI at DA.

Slide 1

Slide 2



Slide 3



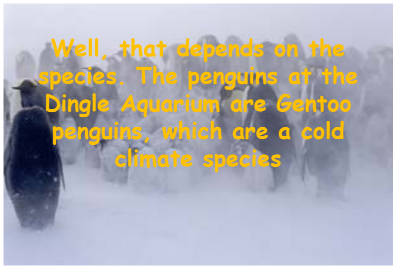
Slide 4

Where do we live?

The Southern Hemisphere

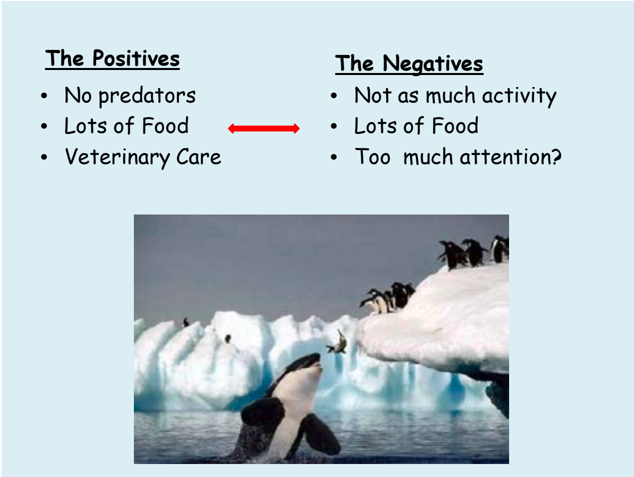
Slide 5

What's the weather like?



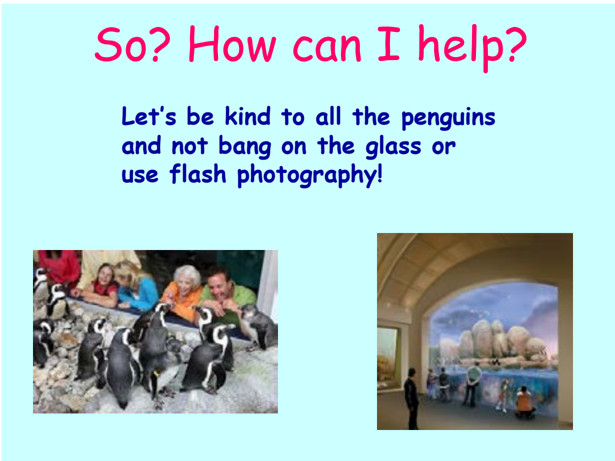
Slide 6

Slide 7



Slide 8

Slide 9



Slide 10

Slide 11

Slide 12

Slide 13

Science

is all around you at the aquarium!

Slide 14

Let's be real scientists

Can you . . . ?

- Knowledge/Observation
- Make a hypotheses – QUESTION
- Experiment
- Discuss/Report what happened and why

Slide 15

Would you like to help make some enrichment devices for the Dingle Aquarium penguins?

Slide 16

Appendix 5: Other work completed

Modules and training courses undertaken during this research:

- PG 6001 - STEPS: Scientific writing and communication module (5 credits)
- PG 6017 - BEES Teaching and learning module (5 credits)
- Effective Education Planning for Outside the Classroom Practitioners Workshop (Chester Zoo, 2013)

Conferences attended:

- International Zoo Educators (IZE) conference, Chester Zoo (August, 2012)
- Irish Science Teachers' Association (ISTA) annual conference, UCC (March, 2015)

Conference presentations:

- Collins, C., Kennedy, D. & O'Riordan, R. (2014). 'Common interests, mutual benefits: UCC and Fota Wildlife Park working together.' *British and Irish Association of Zoos and Aquariums (BIAZA) ACE (marketing and education) conference at Fota Wildlife Park, November, 2014.*
- Collins, C., Kennedy, D. & O'Riordan, R. (2015). 'Influencing visitor behaviour in the zoo setting through the use of environmental enrichment.' *European Zoo Educators' (EZE) conference, Lisbon, Portugal, March 2015.*
- Collins, C., Kennedy, D., O'Riordan, R., Overy, L. & McSweeny-Walsh, L. (2015). 'The relationship and interactions between zoo visitors, captive animals, education and enrichment.' *BIAZA annual research conference (poster), Dublin Zoo, July, 2015.*
- Collins, C. (2015). 'Do better questions lead to evidence of more complex learning?' *Inaugural Symposium of STEM Postgraduate Students' Experience of Teaching and Learning (INSPECT) conference, University College Cork, September, 2015.*
- Collins, C., Kennedy, D. & O'Riordan, R. (2016). 'Environmental Enrichment: Does it work for birds?' *UK and Ireland Regional Environmental Enrichment Conference REEC, Fota Wildlife Park, May, 2016.*

Other presentations:

- Collins, C., Kennedy, D. & O'Riordan, R. (2013). 'A study of the interactions of school children and zoo-housed primates, and the effect of an educational intervention on that relationship.' *Fota Wildlife Park - Board of trustees' conference, November, 2013.*

Non-academic publications

- Collins, C. K. (2015). Monkeying around: Who's learning what at the zoo? The Boolean: Snapshots of postgraduate research at University College Cork 2015.

Appendix 6

PDFs of published papers to date.